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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1902

BY

F. H. NEWELL

PART II.—SOUTHERN ATLANTIC, EASTERN GULF, EASTERN MISSISSIPPI RIVER AND GREAT LAKES DRAINAGE

WASHINGTON

GOVERNMENT PRINTING OFFICE

1903

CONTENTS.

	Page.
Letter of transmittal	9
Introduction	11
Acknowledgments	13
Southern Atlantic coast drainage	15
Roanoke River drainage basin	15
Roanoke River at Neal, N. C	16
Dan River at South Boston, Va	19
Staunton River at Randolph, Va	21
Roanoke River at Roanoke, Va	24
Cape Fear River drainage basin	26
Water powers in Cape Fear River drainage basin	27
Cape Fear River at Fayetteville, N. C	31
Rockfish Creek near Brunt, N. C	48
Deep River at Cumnock, N. C	49
Precipitation over the drainage basin of Cape Fear River	51
Pedee or Yadkin River drainage basin	60
Yadkin River near Salisbury, N. C	61
Yadkin River at Siloam, N. C	64
Miscellaneous measurements in Pedee River drainage basin	68
Santee River drainage basin	68
Catawba River near Rockhill, S. C	71
Catawba River at Catawba, N. C	73
Catawba River near Morganton, N. C	75
John River near Morganton, N. C	77
Linville River near Bridgewater, N. C	80
Broad River of the Carolinas near Alston, S. C	82
Saluda River near Waterloo, S. C	84
Savannah River drainage basin	87
Savannah River at Augusta, Ga	87
Savannah River near Calhoun Falls, S. C	90
Broad River of Georgia near Carlton, Ga	92
Miscellaneous measurements in Savannah River drainage basin	95
Miscellaneous measurements in Ogeechee River drainage basin	95
Altamaha River drainage basin	96
Oconee River near Dublin, Ga	96
Oconee River at Barnett Shoals, Ga	99
Oconee River (Middle) near Athens, Ga	101
Apalachee River near Buckhead, Ga	104
Ocmulgee River at Macon, Ga	107
Ocmulgee River near Flovilla, Ga	110
Alcovy River near Covington, Ga	111
Miscellaneous measurements in Altamaha River drainage basin	113

Page.
Eastern Gulf drainage 114
Apalachicola River drainage basin 114
Flint River at Albany, Ga 114
Flint River near Woodbury, Ga 117
Chattahoochee River at West Point, Ga 119
Chattahoochee River at Oakdale, Ga 122
Chattahoochee River near Gainesville, Ga 125
Miscellaneous measurements in Apalachicola River drainage basin 127
Mobile River drainage basin 128
Cahaba River at Centerville, Ala 129
Alabama River at Selma, Ala 131
Alabama River at Montgomery, Ala 133
Tallapoosa River at Milstead, Ala 134
Tallapoosa River at Sturdevant, Ala 137
Hillabee Creek near Alexander, Ala 139
Talladega Creek at Nottingham, Ala 142
Coosa River at Riverside, Ala 143
Coosa River at Rome, Ga 146
Etowah River at Canton, Ga 148
Coosawatee River at Carters, Ga 151
Black Warrior River at Tuscaloosa, Ala 154
Black Warrior River near Cordova, Ala 156
Black Warrior River (Locust Fork of) at Palos, Ala 159
Tombigbee River at Columbus, Miss 161
Miscellaneous measurements in Mobile drainage 164
Pearl River drainage basin 164
Pearl River at Jackson, Miss 164
Eastern Mississippi River drainage 165
Chippewa River drainage basin 166
Chippewa River near Eau Claire, Wis 166
Black River drainage basin 167
Black River at Melrose, Wis 167
Wisconsin River drainage basin 168
Wisconsin River at Muscoda, Wis 168
Wisconsin River at Necedah, Wis 169
Wisconsin River at Merrill, Wis 170
Rock River drainage basin 170
Catfish River at Madison, Wis 170
Illinois River drainage basin 171
Illinois River at Peoria, Ill 172
Illinois River at La Salle, Ill 172
Illinois River at Ottawa, Ill 172
Fox River at Ottawa, Ill 173
Illinois River near Seneca, Ill 173
Illinois River near Minnoka, Ill 174
Des Plaines River above mouth of Kankakee River, near Channahon, Ill 174
Des Plaines River above Jackson Creek, near Channahon, Ill 175
Wabash River drainage basin 175
Wabash River at Terre Haute, Ind 176
Wabash River at Lafayette, Ind 177
Muskingum River drainage basin 180
Jonathan Creek at Powells, Ohio 181
Licking River at Pleasant Valley, Ohio 181

Eastern Mississippi River drainage—Continued. Page.
Monongahela River drainage basin 182
Youghiogheny River at Friendsville, Md 182
Cheat River at Uneva, near Morgantown, W. Va 184
Kanawha River drainage basin 185
New River at Fayette, W. Va 186
Greenbrier River at Alderson, W. Va 188
New River at Radford, Va 190
New River near Oldtown, Va 191
New River (North Fork) at Weaversford, N. C 194
New River (South Fork) at New River, N. C 198
Cumberland River drainage basin 200
Cumberland River at Nashville, Tenn 200
Miscellaneous measurements in Cumberland River drainage basin 202
Tennessee River drainage basin 202
Tennessee River at Chattanooga, Tenn 203
Hiwassee River at Charleston, Tenn 205
Toccoa River near Blue Ridge, Ga 208
Hiwassee River at Reliance, Tenn 210
Nottely River at Ranger, N. C 212
Hiwassee River at Murphy, N. C 214
Little Tennessee River at Judson, N. C 216
Tuckasegee River at Bryson, N. C 218
Tennessee River at Knoxville, Tenn 220
French Broad River at Oldtown, near Newport, Tenn 223
Pigeon River at Newport, Tenn 223
Nolichucky River near Chucky Valley, Tenn 224
Holston River (South Fork) at Bluff City, Tenn 227
Watauga River at Butler, Tenn 229
Roan Creek at Butler, Tenn 232
Miscellaneous measurements in Tennessee drainage basin 235
Yazoo River drainage basin 235
Yazoo River at Yazoo City, Miss 236
Great Lakes drainage 239
Maumee River drainage basin 239
Maumee River at Waterville, Ohio 239
Blanchard River at Ottawa, Ohio 240
Ottawa River at Lima, Ohio 240
Hydrographic features of Michigan 241
Law of dam construction on Michigan streams 243
Water power in use in Michigan in 1900 245
Hydrographic features of the Upper Peninsula 245
Dead River drainage basin 245
Dead River at The Hoist, near Negaunee, Mich 246
Carp River drainage basin 247
Carp River near Marquette, Mich 248
Menominee River drainage basin 250
Menominee River at Lower Quinnesec Falls, Mich 255
Menominee River near Iron Mountain, Mich 257
Iron River drainage basin 258
Iron River at Riverton Mine, Mich 259
St. Joseph River drainage basin 262
St. Joseph River at Buchanan, Mich 262
St. Joseph River at Mendon, Mich 265

Great Lakes drainage—Continued. Page.
Kalamazoo River drainage basin 266
Kalamazoo River near Allegan, Mich 267
Grand River drainage basin 271
Grand River at Grand Rapids, Mich 272
Crockery Creek at Slocum's Grove, Mich 277
Grand River at North Lansing, Mich 279
Red Cedar River at Agricultural College, Mich 283
Muskegon River drainage basin 285
Muskegon River at Newaygo, Mich 285
Rifle River drainage basin 285
Rifle River at Omer, Mich 286
Au Sable River drainage basin 287
Au Sable River at Bamfield, Mich 288
Thunder Bay River drainage basin 289
Thunder Bay River near Alpena, Mich 289
Low water measurements of streams north of Saginaw Bay 294
Fox River drainage basin 297
Fox River at Omro, Wis 297
Fox River at Oshkosh, Wis 298
Fox River at Wrightstown, Wis 299
Wolf River at Winneconne, Wis 300
Index 301

ILLUSTRATIONS.

		Page.
FIG. 1.	Location of river stations and principal irrigation projects in western half of United States, 1902–3	12
2.	Location of river stations in eastern half of United States, 1902–3	13
3.	Drainage basin of Cape Fear River, showing gaging stations, rainfall stations, and water-power plants	53
4.	Relation of rainfall to run-off, 1889 to 1902, inclusive, in Cape Fear drainage basin	59
5.	Relation of rainfall to run-off for 1898 in Cape Fear drainage basin	59
6.	Relation of rainfall to run-off for 1900 in Cape Fear drainage basin	59
7.	Effect of temperature on run-off in Cape Fear drainage basin	59

LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., May 1, 1903.

SIR: I have the honor to transmit herewith Water-Supply Paper No. 83, which is Part II of the Progress Report of Stream Measurements for 1902. This paper, with Water-Supply Paper No. 82, Part I, of the above report, makes up the report for the territory east of the Mississippi. The report for the territory west of the Mississippi will follow in Water-Supply Papers Nos. 84 and 85.

These papers contain for the various gaging stations the original data as collected and the results obtained from the discussion of these data; also such other information as is of interest in hydrographic studies.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1902.

PART II.

By F. H. Newell

INTRODUCTION.

This paper completes the Progress Report of Stream Measurements for the territory lying east of the Mississippi River, and with Water-Supply Paper No. 82 makes up the complete report for this section. The material in these papers consists of both the original data as collected, and the results obtained from the discussion of these data; also brief descriptions and facts regarding such other subjects as are allied to hydrographic studies. For convenience in arrangement the data in this paper have been grouped by drainage areas. These are arranged in the report geographically as follows: From north to south for those areas which drain into the southern Atlantic; from east to west for those that drain into the eastern Gulf of Mexico; from north to south for those draining into the Mississippi, and from east to west for those draining into the Great Lakes.

On figs. 1 and 2 the relative location of the stations at which the United States Geological Survey is collecting hydrographic data is shown. The section west of the shaded line shows those States which are covered by the national irrigation act of June 17, 1902, and the cross-lined areas show the location of the principal irrigation projects which are now under investigation.

In collecting hydrographic data the Geological Survey has received the hearty cooperation of various individuals, corporations, and States, as mentioned hereafter. This cooperation has made possible the publication of many valuable records which could not otherwise have been obtained.

A brief historical sketch of the stream measurements made by the Geological Survey is published on pages 11–15 of Water-Supply Paper No. 75.

The results of the stream measurements made during past years by the United States Geological Survey can be found in the following publications, which may be consulted at the public libraries in most of our cities:

1893. } Bulletin No. 131.
1894. }

1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11, Part IV of the Eighteenth Annual Report.
1897. Water-Supply Papers Nos. 15 and 16, Part IV of the Nineteenth Annual Report.
1898. Water-Supply Papers Nos. 27 and 28, Part IV of the Twentieth Annual Report.

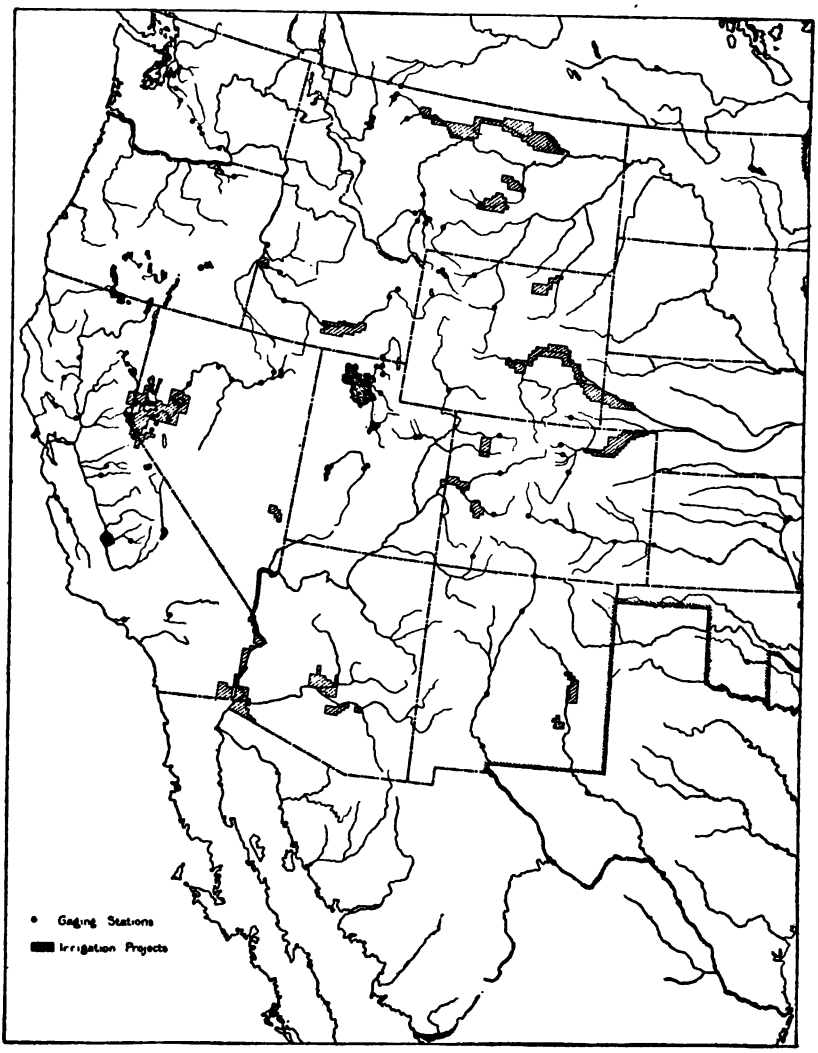

FIG. 1.—Location of river stations and principal irrigation projects in western half of United States, 1902-1903.

1899. Water-Supply Papers Nos. 35 to 39, inclusive, Part IV of the Twenty-first Annual Report.
1900. Water-Supply Papers Nos. 47 to 52, inclusive, Part IV of the Twenty-second Annual Report.
1901. Water-Supply Papers Nos. 65, 66, and 75.
1902. Water-Supply Papers Nos. 82 to 85, inclusive.

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Most of the data presented in this paper have been obtained through local hydrographers and engineers. Acknowledgment is due to each of these persons, and thanks are extended to other persons and corporations who have assisted local hydrographers, or who have coop-

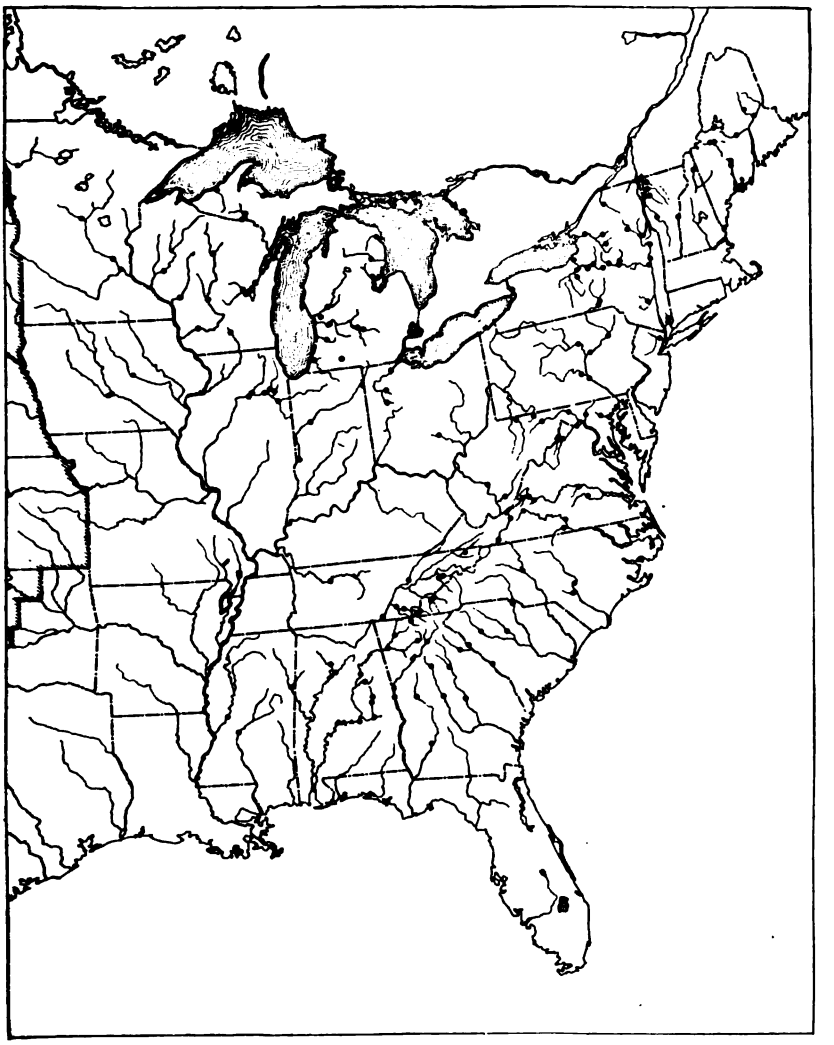

FIG. 2.—Location of river stations in eastern half of United States, 1902-1903.

erated in any way, either by furnishing records or by assisting in transportation.

The following list, arranged geographically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report.

Maryland: Resident hydrographer, E. G. Paul.

Virginia: Resident hydrographers, Prof. D. C. Humphreys and E. W. Myers, assisted by B. S. Drane.

North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Tennessee: Resident hydrographers, Prof. B. M. Hall and Maxcy R. Hall. Thanks are also due to the following individuals and corporations: Prof. W. S. Yates, State geologist of Georgia; for paying the salaries of observers at Barnett Shoals, Buckhead, Covington, Gainesville, Carters, Blueridge, and Canton, Ga.; Dr. Eugene A. Smith, State geologist of Alabama, for the salaries of observers at Sturdevant, Alexander, Nottingham, Riverside, Centerville, Cordova, and Milstead, Ala.; the city of Augusta, Ga., for gage heights at that place. The following Weather Bureau officials have furnished gage heights for the Weather Bureau stations, as noted in the descriptions of stations: D. Fisher, Augusta, Ga.; J. B. Marbury, Atlanta, Ga.; John R. Weeks, Macon, Ga.; F. P. Chaffee, Montgomery, Ala.; W. M. Dudley, Mobile, Ala.; W. S. Belden, Vicksburg, Miss.; L. M. Pindell, Chattanooga, Tenn.; H. C. Bate, Nashville, Tenn. R. C. McCalla, U. S. assistant engineer, has furnished gage heights at Tuscaloosa, Cordova, and Palos, Ala. Transportation has been furnished through the kindness of J. S. B. Thompson, general agent of the Southern Railway; by Capt. E. Berkeley, superintendent of the third division of the Seaboard Air Line; by Thomas K. Scott, general manager of the Georgia Railroad; by James T. Wright, vice-president and general manager of the Macon, Dublin and Savannah Railroad; by John M. Egan, president of the Central of Georgia Railway; by John B. Newton, general manager of the Atlanta, Knoxville and Northern Railway; by W. B. Denham, general superintendent of the Plant System; by Hunter McDonald, chief engineer of the Nashville, Chattanooga and St. Louis Railway; and by W. J. Murphy, general manager of the Queen and Crescent Route.

The stations at Fayetteville, Brunt, Catawba, Cumnock, Murphy, Judson, Neal, Bryson, and Salisbury, N. C.; Alston, Rockhill, and Waterloo, S. C.; and Bluff City, Oldtown, and Newport, Tenn., were under the care of resident hydrographer E. W. Myers, assisted by B. S. Drane. Mr. Myers also prepared the report on the Cape Fear drainage basin.

West Virginia: Resident hydrographer, Prof. D. C. Humphreys.

Ohio: Measurements in this State were mostly made by the late Benjamin H. Flynn, engineer of the state board of health. He was assisted by the engineering department of the Ohio State University, and valuable suggestions were given by William B. Gerrish, M. Am. Soc. C. E., of Oberlin.

Indiana: The gage heights of Lafayette River at Terre Haute have been furnished by D. M. Raubarger. Prof. George E. Waesche, of Purdue University, has furnished the data for Lafayette.

Illinois: Field assistant, E. H. Heilbron. Thanks are also due to the following gentlemen for suggestions and assistance: Isham Randolph, chief engineer, and George W. Wisner, assistant chief engineer, sanitary district of Chicago; L. E. and E. L. Cooley, of Chicago; and Jacob A. Harman, of Peoria.

Wisconsin: The hydrographic work in this State has been carried on in cooperation with the Wisconsin geological and natural history survey, of which E. A. Birge is director and superintendent. Prof. L. S. Smith, engineer of the above survey, has had general charge of the hydrographic work, which has been performed by L. R. Stockman.

Michigan: R. E. Horton, resident hydrographer. Acknowledgment should be made to the following individuals and corporations for services rendered and data furnished: L. W. Anderson, city engineer, Grand Rapids; Prof. H. K. Vedder, agricultural college; Newaygo Portland Cement Co., Newaygo; Fletcher Paper Co., Alpena; Cleveland-Cliffs Iron Co., Negaunee; J. M. Longyear, Marquette; Hugh H. Hosford, Buchannan; F. W. McCoy, Mendon; Dr. A. C. Lane, state geologist, Lansing;

F. M. Warner, secretary of state, Lansing; Kalamazoo Electric Company, Kalamazoo; H. M. Louds Sons Co., Oscoda; Frank Drake, chief engineer of the Oliver Iron Co., Duluth, Minn.

Acknowledgments are also due to John C. Hoyt, George L. Warner, H. G. Stokes, and Frank H. Brundage, for computations on and the arrangement of data of this report.

SOUTHERN ATLANTIC COAST DRAINAGE.

Systematic measurements of discharge of many of the larger rivers of the Southern Atlantic States have been made during the year. The drainage areas of the rivers in that region are in general similar. Most of the streams rise in the southern Appalachian Mountains or their foothills. In the upper part of their courses they are rapid, with considerable fall. Across the Piedmont Plain their valleys are wide and their flow in general is sluggish, with occasional falls over rocky beds. Many of them have falls that could be utilized for water power, and it is largely to that end that data of the flow are being collected. In the study of water power it is important to know the flow and the fall. The fall can readily be determined by an engineer, but the variations in flow often require long and careful study. Gaging stations, to determine the latter, have been established on nearly all the larger streams in the region, and it is hoped that in the near future our information of their fall will be extended.

In this report the areas in this section from which data have been received during 1902 have been grouped as follows, and arranged geographically from north to south:

Roanoke, Cape Fear, Pedee or Yadkin, Santee, Savannah, and Altamaha rivers.

ROANOKE RIVER DRAINAGE BASIN.

Roanoke River, draining a total area of about 9,200 square miles above its mouth, empties into Albemarle Sound a short distance below Plymouth, N. C., and is navigable at all stages as far upstream as Weldon, N. C., where the river crosses the fall line, a distance of 120 miles.

The Roanoke proper is formed by the confluence of the Dan and Staunton rivers, at Clarksville, Mecklenburg County, Va., 185 miles above the mouth of the stream, though the name "Roanoke" is also applied to the upper waters of Staunton River. These streams drain respectively 3,798 square miles and 3,546 square miles. The United States Weather Bureau maintains a gage at Clarksville, and gaging stations on both streams were also maintained here by the Geological Survey for some years.

Of these streams the Staunton is the more northerly, its drainage basin lying entirely in Virginia. It rises among the eastern foothills

of the Blue Ridge to the southwestward of Roanoke and Salem, being known in this part of its course as the Roanoke, and flows at first toward the northeast, then to the southeast, and through Montgomery, Roanoke, Bedford, Campbell, Halifax, and Mecklenburg counties to the junction with the Dan.

A large part of the area drained by the Dan lies in North Carolina. The stream rises in Surry County, N. C., and in Patrick County, Va., and flows at first to the southeast, through Stokes County, N. C., then turns to the northeast through Rockingham and Caswell counties, N. C., and through Pittsylvania, Halifax, and Mecklenburg counties, Va., to the junction with the Staunton.

The average rainfall on the basin of the Roanoke above the fall line is about 48 inches per annum. The average amount probably increases slightly as the stream is ascended, though the records of rainfall over the basin are too incomplete as yet to decide this matter. The amount of rainfall is quite evenly distributed throughout the seasons. This results in a variable flow, since it is probable that the evaporation over the basin is comparatively large.

The freshets on the river are violent, and the fluctuations of height occur with great rapidity. Rises of 50 feet and over have been noted at Weldon, and freshets in which the rate of rise is 10 feet a day or more are frequent.

The maximum recorded flood at the gaging station at Neal occurred in May, 1901, the gage reading being 30.3 feet, and the estimated discharge 84,400 second-feet, equivalent to about 9.7 second-feet per square mile. The minimum flow recorded at this station was 1,380 second-feet, or about 0.16 second-foot per square mile. The maximum flow is thus about 61 times the minimum.

The maximum flow so far recorded for the station on the Dan River at South Boston, Va., is 51,200 second-feet, or about 18 second-feet per square mile, while the greatest flood on the Staunton during the same period at the station at Randolph was 75,100 second-feet, equivalent to about 21 second-feet per square mile of drainage area above the station.

Gaging stations were maintained by the United States Geological Survey during 1902, under the direction of E. W. Myers and D. C. Humphreys, on the Roanoke River proper at Neal, near Kelford, N. C., on the Roanoke (upper portion of the Staunton) at Roanoke, Va., on the Dan at South Boston, Va., and on the Staunton at Randolph, Va.

ROANOKE RIVER AT NEAL, N. C.

This station was established on July 27, 1896, and is on the Norfolk and Carolina Railroad bridge at Neal, near Kelford, N. C.

The zero of the gage rod is over the center of the fourth floor beam of the second span from the north end of the bridge. The distance

from the zero of the rod to the outer rim of the pulley is 2.47 feet, and the distance from the end of the weight to the pointer on the wire is 44.66 feet.

The section is a fairly good one, the course of the river being straight for some distance above and below the station and the bottom smooth. Being muddy, however, the bed is apt to cut out in seasons of high water, and both banks are subject to overflow. The observer is the bridge watchman, W. M. Adams, of Neal, N. C.

The following discharge measurements were made during 1902 by J. S. Henderson and B. S. Drane:

May 9: Gage height, 9.9 feet; discharge, 12,612 second-feet.
July 14: Gage height, 5.4 feet; discharge, 5,805 second-feet.
August 20: Gage height, 6.2 feet; discharge, 4,497 second-feet.
October 15: Gage height, 16.9 feet; discharge, 13,579 second-feet.

Daily gage height, in feet, of Roanoke River at Neal, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	24.45	16.30	27.50	20.70	10.00	5.30	6.60	3.10	2.60	6.30	9.50	11.60
2	27.60	17.20	28.10	19.30	11.20	4.80	7.30	4.30	2.70	6.00	7.70	12.50
3	29.85	21.70	27.80	17.00	10.00	4.50	6.60	4.60	2.40	6.00	6.20	16.50
4	28.15	23.05	27.75	14.90	9.65	4.30	6.20	5.30	2.90	6.80	5.30	20.00
5	25.90	24.10	26.60	13.60	11.70	4.20	5.50	5.10	4.00	6.30	4.90	22.50
6	23.50	24.20	24.80	12.50	11.80	4.00	4.60	4.50	6.00	5.20	4.70	22.70
7	20.70	22.90	23.70	12.00	11.45	3.80	3.75	3.80	5.50	17.60	4.40	23.15
8	18.05	20.40	22.70	12.20	9.45	3.80	3.20	3.20	5.35	23.02	4.40	23.45
9	16.00	18.10	21.30	17.50	9.60	3.80	4.30	3.00	4.60	23.65	5.30	22.00
10	14.50	16.10	19.50	19.90	10.50	3.80	5.90	3.20	3.90	21.65	5.75	19.35
11	13.30	14.30	18.30	20.00	10.40	3.80	5.40	3.30	5.30	19.00	5.80	16.90
12	12.30	12.60	17.30	18.60	9.75	3.90	5.10	3.10	6.60	14.90	5.30	14.80
13	11.40	11.50	16.00	16.30	7.80	3.70	6.55	(a)	5.25	15.00	4.90	13.05
14	10.50	10.70	14.90	14.50	7.00	3.50	6.10	.....	4.50	18.00	4.60	12.10
15	9.50	10.00	14.00	13.20	6.60	3.20	4.70	.....	4.00	17.30	4.40	12.00
16	8.50	9.50	13.10	12.30	6.50	3.40	3.80	.....	3.40	13.90	4.30	12.70
17	7.85	9.10	12.60	11.60	6.80	3.70	3.30	.....	2.85	11.10	4.20	12.30
18	7.90	9.00	13.50	11.20	7.40	18.25	3.00	.....	2.55	19.00	4.10	12.80
19	8.00	9.10	20.10	10.90	10.90	21.60	2.80	.....	2.40	7.40	4.30	17.45
20	7.95	9.00	19.80	10.60	10.90	20.80	2.40	6.33	2.30	6.30	4.70	18.30
21	7.50	8.60	17.80	10.30	9.70	16.90	2.20	5.00	2.20	5.65	13.30	16.10
22	9.40	10.50	15.80	9.80	9.30	13.80	2.00	3.85	2.20	5.10	13.20	14.20
23	15.80	13.20	14.50	9.30	8.70	11.25	2.20	3.40	2.30	4.70	10.70	17.00
24	17.00	17.20	13.40	9.05	7.60	8.65	2.00	3.00	2.30	4.50	8.60	18.40
25	16.40	19.80	12.60	8.60	6.50	6.90	2.30	3.80	2.30	4.30	7.20	18.30
26	14.10	22.20	11.80	8.30	5.90	6.00	2.40	3.30	2.40	4.20	6.95	16.10
27	12.40	23.65	11.10	8.00	6.10	5.10	2.35	3.10	2.50	4.00	7.80	13.90
28	12.00	25.65	10.50	7.70	6.60	4.90	2.20	3.00	2.50	3.90	13.60	12.30
29	11.70	.....	10.10	7.50	6.45	5.60	1.80	3.20	3.80	4.00	15.00	10.90
30	13.90	.....	12.50	7.50	6.10	5.70	1.70	3.40	6.10	9.75	13.20	9.40
31	15.00	.....	19.00	.....	5.60	.....	1.80	2.90	.....	11.20	.....	8.85

a Gage wire broken August 13 to 19.

Rating table for Roanoke River at Neal, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	1,920	4.0	3,980	7.0	6,230	13.0	12,730
1.2	2,050	4.2	4,120	7.2	6,420	13.5	13,380
1.4	2,180	4.4	4,260	7.4	6,610	14.0	14,030
1.6	2,310	4.6	4,400	7.6	6,800	14.5	14,730
1.8	2,440	4.8	4,540	7.8	7,000	15.0	15,430
2.0	2,580	5.0	4,680	8.0	7,200	15.5	16,180
2.2	2,720	5.2	4,830	8.5	7,700	16.0	16,930
2.4	2,860	5.4	4,980	9.0	8,200	16.5	17,730
2.6	3,000	5.6	5,130	9.5	8,730	17.0	18,530
2.8	3,140	5.8	5,280	10.0	9,280	17.5	19,405
3.0	3,280	6.0	5,430	10.5	9,830	18.0	20,280
3.2	3,420	6.2	5,590	11.0	10,380	19.0	22,130
3.4	3.560	6.4	5,750	11.5	10,955	20.0	24,230
3.6	3,700	6.6	5,910	12.0	11,530	25.0	46,500
3.8	3,840	6.8	6,070	12.5	12,130	30.0	82,000

Estimated monthly discharge of Roanoke River at Neal, N. C.

[Drainage area, 8,717 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	80,800	6,705	21,294	2.44	2.81
February	50,202	7,800	20,529	2.36	2.46
March	67,250	9,390	26,139	3.00	3.46
April	25,910	6,705	13,258	1.52	1 70
May	11,300	5,130	7,965	.91	1.05
June	28,650	3,420	7,493	.86	.96
July	6,515	2,375	3,916	.45	.52
August 1 to 12 and 20 to 31	.....	.....	[a] 3,833	[a] .44	[a] .39
September	5,910	2,720	3,703	.42	.47
October	39,075	3,910	11,793	1.35	1.56
November	15,430	4,050	6,795	.78	.87
December	37,975	8,050	18,288	2.10	2.42

[a] Partial month.

DAN RIVER AT SOUTH BOSTON, VA.

This station, which was established on August 27, 1900, by E. W. Myers, is in the town of South Boston, Va., on the railroad bridge of the Norfolk and Western Railroad which crosses the river at that place. The gage rod is laid off on the downstream guard rail of the bridge, the graduations being indicated by brass nails driven into the rail. The zero of the rod is exactly over the center of the first span from the north end of the bridge. The distance between the zero of the rod and the outer rim of the pulley is 2.39 feet, and the distance between the end of the weight and the pointer on the wire rope is 36.44 feet. When the gage reading is 1 foot the water surface is 31.06 feet below the top of the head of the nut on the pin connecting the two tension rods with the lower chord of the bridge, this pin being on the lower side of the bridge and exactly opposite the zero of the gage. This is a very good station for the gaging of all except the very highest stages of flow. At extreme heights the river spreads out over a flood plain of considerable width. The trestle connecting the bridge with the embankment on the south side of the river is a curve of rather high degree. The bed of the stream is of coarse sand and probably shifts only slightly. C. T. Nichols, South Boston, Va., is the observer.

The following discharge measurements were made during 1902 by B. S. Drane:

July 9: Gage height, 1.90 feet; discharge, 1,551 second-feet.
August 15: Gage height, 1.65 feet; discharge, 1,333 second-feet.
October 13: Gage height, 7.95 feet; discharge, 6,864 second-feet.
December 5: Gage height, 8.90 feet; discharge, 9,197 second-feet.

Daily gage height, in feet, of Dan River at South Boston, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	19.50	8.70	18.35	7.75	5.30	3.90	4.75	1.40	1.10	2.70	1.70	4.50
2	8.00	13.10	15.10	6.60	5.05	3.85	4.45	1.40	1.10	2.60	1.80	7.30
3	6.70	14.20	11.00	5.90	4.75	3.70	4.20	1.35	1.20	2.60	1.80	10.70
4	6.00	8.50	8.15	5.50	4.55	3.60	4.00	1.45	1.20	2.50	1.90	13.20
5	5.20	6.70	7.80	5.50	4.55	3.50	3.90	1.30	1.30	6.80	1.90	9.65
6	4.60	5.50	8.60	5.50	4.90	3.35	2.60	1.20	1.40	7.25	2.00	10.95
7	4.60	5.30	7.40	5.50	5.00	3.05	2.00	1.20	1.50	6.90	2.30	10.65
8	4.70	5.20	6.55	7.75	5.05	2.90	1.90	1.20	1.60	6.40	2.30	6.85
9	4.60	4.90	6.50	9.45	5.25	2.90	1.70	1.20	1.70	5.90	2.30	4.55
10	4.50	4.50	6.50	7.20	4.95	3.05	2.60	1.10	1.70	6.15	2.30	4.10
11	4.40	4.10	6.00	6.55	4.65	3.20	3.20	1.10	1.60	6.75	2.20	4.10
12	4.10	4.00	5.65	6.05	4.60	3.10	2.90	1.20	1.40	7.90	2.20	4.10
13	3.80	3.90	5.20	5.60	4.70	3.00	2.10	1.20	1.30	8.50	2.20	4.00
14	3.60	3.80	4.70	5.50	4.70	3.00	1.65	1.30	1.20	8.10	2.20	4.00
15	3.50	3.80	5.10	5.40	4.70	2.90	1.30	1.60	1.10	5.70	2.30	4.00
16	3.70	3.90	5.70	5.35	4.85	3.40	1.30	1.80	1.00	3.70	2.30	4.00

Daily gage height, in feet, of Dan River at South Boston, Va.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
17	4.00	4.00	8.20	5.45	5.05	8.30	1.40	1.70	.90	2.50	2.50	3.90
18	3.80	4.10	7.70	5.75	5.45	16.45	1.50	1.30	.80	2.10	2.60	3.65
19	3.50	3.80	7.20	5.80	5.25	8.85	1.40	1.20	.70	1.80	2.60	3.45
20	3.80	4.00	6.30	5.65	5.05	5.00	1.30	1.10	.70	1.80	2.60	3.30
21	4.80	4.10	6.00	5.55	4.90	4.45	1.30	1.20	.70	1.80	2.70	3.15
22	5.65	5.20	5.50	5.30	4.80	3.35	1.30	1.30	1.00	1.70	2.70	3.00
23	7.75	6.10	5.65	5.05	4.95	3.00	1.20	1.65	1.50	1.60	2.80	3.00
24	5.30	7.20	5.80	4.90	5.10	2.90	1.10	1.70	2.60	1.60	2.70	2.90
25	5.20	13.35	5.70	4.80	5.10	2.90	1.10	1.45	3.05	1.50	2.70	2.80
26	5.10	18.55	5.10	4.70	5.10	2.80	1.05	1.15	4.20	1.40	2.50	2.80
27	5.00	18.40	5.00	4.85	5.00	2.80	1.10	1.00	4.35	1.50	2.40	2.80
28	4.80	12.85	5.15	4.95	4.65	3.45	1.30	1.00	3.75	1.60	2.30	2.80
29	4.80	.....	9.35	5.70	4.45	4.30	1.30	1.00	3.15	1.70	2.65	2.90
30	4.90	.....	15.80	5.20	4.15	4.85	1.30	1.10	2.90	1.70	3.30	2.90
31	4.90	.....	12.05	.....	4.00	.....	1.30	1.10	.....	1.70	.....	2.90

Rating table for Dan River at South Boston, Va., for 1902.

Gage height.	Discharge	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.7	900	3.8	2,930	7.0	6,000	13.5	14,000
.8	950	4.0	3,100	7.2	6,200	14.0	14,900
1.0	1,050	4.2	3,280	7.4	6,400	14.5	15,950
1.2	1,150	4.4	3,460	7.6	6,600	15.0	17,000
1.4	1,250	4.6	3,640	7.8	6,800	15.5	18,200
1.6	1,360	4.8	3,820	8.0	7,000	16.0	19,400
1.8	1,480	5.0	4,000	8.5	7,550	16.5	20,750
2.0	1,600	5.2	4,200	9.0	8,100	17.0	22,100
2.2	1,730	5.4	4,400	9.5	8,700	17.5	23,550
2.4	1,860	5.6	4,600	10.0	9,300	18.0	25,000
2.6	2,000	5.8	4,800	10.5	9,900	18.5	26,600
2.8	2,150	6.0	5,000	11.0	10,500	19.0	28,200
3.0	2,300	6.2	5,200	11.5	11,100	19.5	30,000
3.2	2,450	6.4	5,400	12.0	11,700	20.0	31,800
3.4	2,600	6.6	5,600	12.5	12,400		
3.6	2,760	6.8	5,800	13.0	13,100		

Estimated monthly discharge of Dan River at South Boston, Va.

[Drainage area, 2,750 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	30,000	2,675	4,738	1.72	1.98
February	26,760	2,930	7,105	2.58	2.69
March	26,120	3,730	7,269	2.64	3.04
April	8,640	3,730	4,834	1.76	1.96
May	4,450	3,100	3,876	1.41	1.63
June	20,615	2,150	3,535	1.29	1.44
July	3,775	1,075	1,713	.62	.71
August	1,480	1,050	1,197	.44	.51
September	3,415	900	1,545	.56	.62
October	7,550	1,250	3,158	1.15	1.33
November	2,525	1,420	1,842	.67	.75
December	13,460	2,150	4,186	1.52	1.75
The year	30,000	900	3,750	1.36	18.41

STAUNTON RIVER AT RANDOLPH, VA.

This station, which was originally established on August 27, 1900, by E. W. Myers, is on the railroad bridge about five-eighths of a mile southwest of Randolph station on the line of the Southern Railway from Richmond to Danville. During the months of July, August, and September the old bridge was replaced, and readings were taken on a temporary gage during that time. The present gage was put in on October 13, 1902, by B. S. Drane. The gage rod is of pine, well painted, graduated to feet and tenths, and nailed to the outside of the upstream guard rail, the zero of the rod being exactly over the center of the second span from the north end of the bridge. The distance from the zero of the rod to the outer rim of the pulley is 3.18 feet, and that from the end of the weight to the pointer on the wire rope is 45.23 feet. When the gage reads zero the water surface is 38.91 feet below the upper edge of the hexagonal nut on the pin opposite the zero of the gage, on the upstream side of the bridge. The present gage reads the same as the one it replaced.

The river is straight for a long distance above and below the station, and the velocity of the current is well distributed. The rise at this point is 25 feet or more. It is not probable that the channel changes

to any considerable extent during high water. The observer at this station is Justin Field, station agent at Randolph.

The following discharge measurements were made during 1902 by B. S. Drane:

August 15: Gage height, 4.05 feet; discharge, 2,312 second-feet.
October 13: Gage height, 9.15 feet; discharge, 6,203 second-feet.
December 5: Gage height, 13.45 feet; discharge, 10,921 second-feet.

Daily gage height, in feet, of Staunton River at Randolph, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	19.00	10.20	23.70	7.50	5.50	3.90	5.10	3.70	2.30	4.20	4.20	9.00
2	10.50	12.50	21.20	6.80	5.10	3.90	5.00	5.10	2.30	4.00	4.00	11.50
3	8.90	17.50	14.20	6.30	6.40	3.90	4.20	4.40	3.20	3.70	3.85	16.00
4	7.90	11.50	9.90	5.90	7.00	3.80	3.80	3.90	3.00	3.70	3.80	13.40
5	6.90	7.90	10.60	6.00	5.50	3.85	3.70	3.50	3.70	8.60	3.80	13.70
6	6.10	6.40	10.90	6.50	5.40	3.70	3.50	3.90	3.30	23.00	3.80	15.05
7	6.00	6.00	8.70	5.80	5.30	3.60	5.30	4.30	3.00	20.00	4.10	10.20
8	6.05	6.20	8.00	10.30	6.70	3.90	4.80	3.80	2.60	5.60	4.10	8.00
9	5.90	5.70	8.30	11.20	6.00	3.90	4.30	3.80	4.00	5.10	4.10	6.90
10	5.80	5.00	8.40	8.40	5.50	3.70	4.55	3.50	3.00	4.50	3.80	6.10
11	5.70	4.95	7.70	7.10	5.20	3.60	4.60	3.90	3.40	5.00	3.75	5.80
12	5.50	4.90	7.30	6.60	4.80	3.50	3.60	3.30	3.00	10.00	3.70	5.55
13	4.90	4.90	6.90	6.20	4.80	3.40	3.40	3.05	2.70	8.80	3.70	6.20
14	4.50	4.90	6.60	6.00	4.70	3.50	3.10	3.60	2.50	6.00	3.65	6.40
15	4.50	4.90	6.30	6.10	4.70	6.00	3.00	3.80	2.50	5.20	3.65	6.20
16	4.90	4.85	6.80	5.90	4.60	11.10	2.80	7.40	2.50	4.70	3.60	6.50
17	4.90	4.90	14.30	5.80	4.50	18.30	2.60	4.30	2.50	4.40	3.50	9.20
18	4.80	4.80	10.30	5.60	5.00	8.10	2.50	3.70	2.50	4.20	3.60	10.60
19	4.75	4.60	8.30	5.50	4.70	5.60	2.50	3.30	2.50	4.10	5.10	8.10
20	4.70	4.70	7.30	5.40	4.65	4.70	2.60	2.70	2.50	3.90	5.00	7.00
21	5.20	5.10	6.75	5.30	4.70	4.50	2.80	2.70	2.50	3.80	5.40	6.40
22	8.50	9.00	6.40	5.20	4.70	4.10	3.50	2.70	2.80	3.75	5.00	8.00
23	8.50	9.50	6.20	5.15	4.75	4.00	3.00	2.70	2.80	3.70	4.50	8.00
24	6.50	11.50	6.00	5.10	4.75	3.90	2.80	2.50	2.70	3.70	4.30	7.00
25	5.40	19.20	5.80	5.00	5.60	3.80	2.70	2.40	2.70	3.65	6.00	6.30
26	5.40	26.50	5.65	4.90	4.70	4.20	2.60	2.50	2.70	3.60	11.00	5.85
27	7.60	24.00	5.50	4.90	4.60	4.50	2.60	3.30	4.10	3.60	11.40	5.20
28	10.20	20.20	5.50	4.80	4.40	4.60	2.50	2.70	4.40	8.10	8.10	4.90
29	10.20	.....	10.60	6.90	4.20	4.50	2.50	3.30	3.40	6.70	7.00	4.70
30	7.70	.....	12.20	6.50	4.10	5.60	2.40	2.70	3.00	5.00	7.00	5.50
31	7.70	.....	9.00	.....	4.00	.....	3.90	2.50	.....	4.40	.....	5.40

Rating table for Staunton River at Randolph, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	1,400	5.2	3,360	9.0	7,250	17.0	21,200
2.2	1,490	5.4	3,520	9.5	7,875	17.5	22,450
2.4	1,580	5.6	3,680	10.0	8,500	18.0	23,700
2.6	1,670	5.8	3,840	10.5	9,150	18.5	24,950
2.8	1,760	6.0	4,000	11.0	9,800	19.0	26,200
3.0	1,850	6.2	4,190	11.5	10,600	19.5	27,600
3.2	1,960	6.4	4,380	12.0	11,400	20.0	29,000
3.4	2,070	6.6	4,570	12.5	12,200	20.5	.....
3.6	2,180	6.8	4,760	13.0	13,000	21.0	.....
3.8	2,290	7.0	4,950	13.5	13,900	21.5	.....
4.0	2,400	7.2	5,160	14.0	14,800	22.0	.....
4.2	2,560	7.4	5,370	14.5	15,800	22.5	.....
4.4	2,720	7.6	5,580	15.0	16,800	23.0	.....
4.6	2,880	7.8	5,790	15.5	17,850	24.0	.....
4.8	3,040	8.0	6,000	16.0	18,900	25.0	.....
5.0	3,200	8.5	6,625	16.5	20,050		

Estimated monthly discharge of Staunton River at Randolph, Va.

[Drainage area, 3,076 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	26,200	2,800	5,388	1.75	2.02
February	51,050	2,880	10,292	3.35	3.49
March	40,495	3,600	8,616	2.80	3.23
April	10,120	3,040	4,398	1.43	1.60
May	4,950	2,400	3,250	1.06	1.22
June	24,450	2,070	3,656	1.19	1.33
July	3,440	1,580	2,149	.70	.81
August	5,370	1,580	2,198	.71	.82
September	2,720	1,535	1,844	.60	.67
October	38,150	2,180	5,307	1.73	1.99
November	10,440	2,125	3,347	1.09	1.22
December	18,900	2,960	6,578	2.14	2.47
The year	51,050	1,535	4,752	1.55	20.87

ROANOKE RIVER AT ROANOKE, VA.

This river rises in Montgomery County, Va. Its headwaters are near those of New River on the west. This stream lower down is known as Staunton River, and joins the Dan at Clarksville to form the main lower Roanoke River. There are a number of fine water powers along its length, described more fully in the Nineteenth Annual Report, Part IV, page 176. The gaging station was established by D. C. Humphreys on July 10, 1896, and is located at the edge of the city of Roanoke, Va., on the Walnut street bridge. The gage is of wire, with the rod fastened to the floor of the bridge. The top of the lower end of the first floor beam is 21.99 feet above gage datum. The length of gage wire is 24.39 feet. The right bank is above high water, but the left is liable to overflow in extreme high stages. The channel is nearly straight and the current good.

The following discharge measurements were made during 1902 by D. C. Humphreys:

July 10: Gage height, 1.09 feet; discharge, 199 second-feet.
August 21: Gage height, 0.63 foot; discharge, 78 second-feet.

Daily gage height, in feet, of Roanoke River at Roanoke, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.20	2.17	3.90	2.45	1.38	1.05	1.35	1.05	0.60	0.70	0.85	2.30
2	3.76	2.30	3.40	2.00	1.35	1.00	1.20	.90	.60	.75	.80	1.00
3	2.15	2.30	3.09	1.95	1.45	1.03	1.05	.82	.60	.68	.80	2.90
4	2.00	2.35	2.75	1.90	1.35	1.00	1.00	.80	.60	.68	.85	2.20
5	1.90	2.25	2.40	1.90	1.35	1.00	.90	.90	.60	1.95	.80	2.55
6	1.85	2.05	2.23	1.80	1.30	1.00	.95	.90	.60	1.50	.90	2.30
7	1.80	1.91	2.15	1.75	1.30	1.00	.95	.80	.60	1.00	.90	1.95
8	1.75	1.77	2.32	1.68	1.35	1.00	.95	.70	.60	.85	.85	1.75
9	1.70	1.65	2.43	1.75	1.35	1.10	1.60	.70	.60	.75	.83	1.60
10	1.70	1.55	2.33	1.85	1.29	1.05	1.10	.70	.65	.70	.80	1.50
11	1.65	1.48	2.20	1.93	1.25	1.00	.95	.70	.65	.80	.75	1.45
12	1.47	1.40	2.15	2.00	1.22	.95	.95	.70	.63	1.05	.80	1.40
13	1.30	1.34	2.09	1.93	1.22	.93	.90	.68	.60	1.00	.78	1.40
14	1.25	1.30	2.03	1.80	1.25	1.00	.85	.70	.60	.90	.80	1.50
15	1.40	1.25	1.98	1.73	1.29	1.05	.85	.68	.60	.85	.80	1.50
16	1.50	1.21	2.03	1.73	1.25	1.25	.80	.70	.60	.80	.80	1.50
17	1.43	1.18	2.95	1.66	1.20	1.25	.80	.70	.60	.75	.80	2.40
18	1.38	1.15	2.50	1.65	1.19	1.15	.75	.65	.60	.75	1.70	2.20
19	1.30	1.15	2.25	1.63	1.19	1.10	.70	.65	.60	.75	1.60	1.90
20	1.35	1.20	2.12	1.63	1.19	1.05	.70	.65	.60	.75	1.30	1.70
21	1.50	1.35	2.00	1.63	1.25	1.05	.70	.65	.60	.70	1.15	1.60
22	1.67	1.70	1.95	1.55	1.20	1.00	.70	.65	.65	.70	1.05	1.75
23	1.75	2.10	1.70	1.50	1.15	1.00	.70	.65	.65	.70	1.00	1.65
24	1.60	2.15	1.64	1.50	1.15	1.00	.92	.63	.63	.70	1.00	1.55
25	1.53	10.06	1.50	1.50	1.12	1.00	.85	.61	.65	.73	1.15	1.50
26	1.40	5.15	1.45	1.50	1.12	1.25	.78	.60	.70	.75	2.10	1.40
27	1.80	5.50	1.40	1.48	1.13	1.25	.70	.60	.70	.80	2.40	1.10
28	2.95	8.75	2.05	1.45	1.12	1.25	.70	.60	.70	.93	1.80	1.30
29	2.80	.....	3.50	1.50	1.10	1.35	.72	.60	.65	1.10	1.65	1.30
30	2.71	.....	3.00	1.50	1.10	1.35	1.22	.60	.63	.90	1.40	1.30
31	2.35	.....	2.73	.....	1.08	.....	1.15	.60	.....	.90	.....	1.20

Rating table for Roanoke River at Roanoke, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	25	3.0	1,960	5.8	5,728	9.5	10,760
0.4	55	3.2	2,228	6.0	6,000	10.0	11,440
0.6	85	3.4	2,496	6.2	6,272	10.5	12,120
0.8	120	3.6	2,764	6.4	6,544	11.0	12,800
1.0	170	3.8	3,032	6.6	6,816	11.5	13,480
1.2	240	4.0	3,300	6.8	7,088	12.0	14,160
1.4	325	4.2	3,568	7.0	7,360	12.5	14,840
1.6	429	4.4	3,836	7.2	7,632	13.0	15,520
1.8	554	4.6	4,104	7.4	7,904	13.5	16,200
2.0	688	4.8	4,372	7.6	8,176	14.0	16,880
2.2	888	5.0	4,640	7.8	8,448	14.5	17,560
2.4	1,156	5.2	4,912	8.0	8,720	15.0	18,240
2.6	1,424	5.4	5,184	8.5	9,400		
2.8	1,692	5.6	5,456	9.0	10,080		

Estimated monthly discharge of Roanoke River at Roanoke, Va.

[Drainage area, 388 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	4,912	260	944	2.43	2.80
February	11,508	222	1,576	4.06	4.23
March	3,166	325	1,143	2.95	3.40
April	1,223	349	525	1.35	1.51
May	349	205	255	.66	.76
June	302	154	200	.52	.58
July	429	100	156	.40	.46
August	187	85	103	.27	.31
September	100	85	89	.23	.26
October	654	100	149	.38	.44
November	1,156	110	251	.65	.73
December	1,826	205	574	1.48	1.71
The year	11,508	85	497	1.28	17.19

CAPE FEAR RIVER DRAINAGE BASIN.

Cape Fear River is formed by the junction, near Moncure, in Chatham County, N. C., of Haw and Deep rivers. It is usual to consider the Haw, the Deep, and the Cape Fear as each a separate stream with an individual and independent existence of its own, irrespective of the others; and to a certain extent in a consideration of the physical features of the entire drainage basin this method of treatment is desirable. All of these streams, however, form a single river system, and it is more convenient to treat of the basin as a whole in parts of what follows.

Viewed from this standpoint, Cape Fear River rises among the red clay hills of Guilford and Rockingham counties, N. C., the sources of Haw and Deep rivers being but a short distance apart. Haw River is the more northerly of the two branches, and flows at first slightly toward the northeast, but turning soon to the southeast drains the southern portion of Rockingham County and the greater part of Guilford, and passes thence through Alamance, a corner of Orange, and Chatham County to its junction with the Deep River in the lower part of Chatham. Deep River flows at first toward the south, but soon turns to the southeast and flows practically parallel with Haw River for many miles through Guilford and Randolph counties, and into Moore County, where it turns abruptly toward the east, flowing in this direction through Moore and Chatham counties to the junction with the Haw.

The area drained by the entire river system above the town of Fayetteville, N. C., the head of navigation on the river, is 4,493 square miles, of which Haw River drains 1,800, Deep River 1,400, and Cape Fear River below the junction 1,293 square miles. The form and general dimensions of the basin are shown on the accompanying map.

The elevations of the divides between the drainage basin of the Cape Fear system and those of the adjacent streams are not very great, and the minor tributaries can not therefore furnish much power except in places where considerable storage may be obtained by the construction of suitable dams.

The declivity of the main streams is shown in the following tables:

Table of declivity, Cape Fear River.

Locality.	Distance from Fayetteville.	Elevation above tide.	Distance between points.	Fall between points.	Average fall between points, per mile.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Fayetteville	0.0	22.5	.....	.....	.....
Foot Smileys Falls[a]	25.0	53.8	25	31.3	1.252
Head Smileys Falls	36.0	110.2	11	56.4	5.127
Junction of Haw and Deep rivers	58.0	155.3	22	45.1	2.050

[a] In the above table Smileys Falls has been taken to include the entire long rapids or series of rapids in which this river crosses the fall line, though the name is properly applied only to the lower 3.5 miles of this distance, the descent in the falls proper being 27 feet.

Table of declivity, Haw River.

Locality.	Distance from junction of Haw and Deep rivers.	Elevation above tide.	Distance between points.	Fall between points.	Average fall between points per mile.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Confluence with Deep River	0.0	155.3	.....	.....	.....
Haw River station	50.0	476.0	50	320.7	6.4
Haw River at Southern Railway crossing	77.0	647.0	27	171.0	6.3
Reedy Fork of Haw River at Southern Railway crossing	80.0	676.0	30	200.0	6.7

Table of declivity, Deep River.

Locality.	Distance from junction of Haw and Deep rivers.	Elevation above tide.	Distance between points.	Fall between points.	Average fall between points per mile.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Confluence with Haw River	0.0	155.3	.....	.....	.....
Egypt	14.0	204.6	14	49.3	3.52
Jamestown	100.0	715.0	86	510.4	5.93

WATER POWERS IN CAPE FEAR RIVER DRAINAGE BASIN.

As will be seen by reference to the map of the basin, the water power interests of the main Cape Fear River below the junction of Deep and Haw rivers are relatively unimportant at present, though

important developments are now in progress and others are understood to be in contemplation.

The first of the developments now in progress is located on Smileys Falls, which have been previously mentioned. The site of the development is located about 28 miles above Fayetteville, at a point known as Narrow Gap, from the fact that in the ledge of rock from three to four feet high which crosses the river at this point a small gap occurs, through which at low water the entire flow of the stream passes. A stone dam will be built across the stream and the power thus developed will be used in the operation of a large cotton mill now in course of construction.

The second locality at which development work has been done is at Buckhorn Falls, located a short distance below the junction of Haw and Deep rivers. The project for this place includes the development of the power at Lockville, on Deep River, a short distance above the junction with the Haw, and the electrical transmission of the power to Fayetteville and other manufacturing towns. Many contracts for the power have been made.

The power possibilities of the stream are developed to a much greater extent on Haw and Deep rivers, which are the most important manufacturing streams in the State in respect to number of mills operated. Haw River and its tributaries operate 11 cotton mills, while Deep River operates 10 cotton mills and a number of flour mills. There are several fine power sites still available on Haw River and a number on Deep River.

Unfortunately Cape Fear, Deep, and Haw rivers are subject to floods of greater violence than are experienced on any other North Carolina stream. At times the Cape Fear at Fayetteville has risen to a height of 58 feet above low water, and there are records of one flood exceeding 60 feet above low water at this place, the height being recorded on the same gage. This extreme high water is not caused by greater violence and magnitude of precipitation over the drainage basin of the stream than on the basins of the other rivers of the State, for the flood discharge per unit of area for the basin of the Cape Fear is less than those of many of the other rivers where the flood rise is not so great; but below Fayetteville there is a considerable diminution in the slope of the channel, and, in addition, the channel becomes U-shaped at this point, the sides of the trough being very high and the bottom only wide enough for the dry-weather flow.

At points farther upstream where the slope is greater and the channel of different shape, the extreme rise in some places does not exceed 20 feet, though the volume of water to be passed does not greatly differ from that which flows past Fayetteville. The rise in flood is less on the upper 30 miles of the course of the Cape Fear than on the Deep and the Haw, on which streams near their junction floods of 25 feet rise and over have many times occurred.

Many of the tributaries of these streams rise and flow in a slate country, where the soil is either very thin or, in many instances, washed away entirely, and where the topography is broken. In such a country the hills shed the storm waters into the streams with great rapidity, not only producing thus the floods just mentioned, but also, since little subterranean storage is possible in a country of this character, making the dry-weather flow extremely small. Many of the smaller streams are completely dry in time of severe drought. The slate country covers a large proportion of the entire area drained by the stream above Fayetteville, and, as a consequence, the flow of the Cape Fear, and in a greater degree that of the Deep and the Haw, becomes during severe drought very small in proportion to area drained. The mean discharge for the basin above Fayetteville, for an entire month, has fallen as low as 0.12 second-foot per square mile, while the minimum recorded flow is equivalent to only 0.069 second-foot per square mile. This remarkably low stage occurred in October, 1900. The next lowest stage occurred in October, 1897, the volume being 340 second-feet, equivalent to 0.073 second-foot per square mile of area above Fayetteville.

Low as these rates of flow seem, it is a matter of practical certainty that a large portion of the basin discharges at such times at a much lower rate, although there are, unfortunately, no direct measurements of the flow of any of the tributaries made at such times to prove the statement. However, the governing conditions are very similar over portions of the area drained by the Neuse River, whose drainage basin borders that of the Cape Fear on the north, and whose head streams are interlaced with those of the Cape Fear. A weir measurement of the flow of Eno River, one of the head streams of the Neuse River, at a point where the drainage area, as measured from the best maps available, is about 100 square miles, gave a flow of only 3,000,000 gallons per twenty-four hours, or 4.64 second-feet, which is at the rate of 0.046 second-foot per square mile. This measurement was made during the severe drought of 1897, at the time when the flow of Cape Fear River reached so low a stage.

For a clearer discussion of the physical features of the drainage basin, and of the effect of such features on the flow of the stream, the entire area above Fayetteville will be divided as follows: (1) That part of the basin lying below the junction of Haw and Deep rivers; (2) the area drained by Haw River; and (3) the area drained by Deep River.

The area drained by Cape Fear River, below the junction of the Haw and the Deep, may, topographically, be divided into two parts, the first and largest including the sand-hill belt, the second all the remainder of the area, which is characterized by different geologic formations.

The sand-hill belt forms the largest part of the drainage basin of Cape Fear River below the junction of the Haw and the Deep, and

exerts an important influence on the character and distribution of the flow of the streams rising and flowing in it, and consequently on the flow of Cape Fear River, to which these streams are tributary. This region is a belt of sand hills from 30 to 40 miles in width, located, as a rule, immediately below the fall line, though at times extending above it, and consisting of broad and flattened swells, which are usually well wooded with long-leaf pine, and generally with an undergrowth. During comparatively recent years, however, a considerable part of the timber of this region has been removed, and the sand hills are now covered in many places with a sparse growth of scrub oaks, which barely shades the soil, and in other places with the charred remains of the original pines, and with a straggling growth of a coarse species of grass.

The deposit of sand varies in thickness from a foot or two to about 100 feet, depending somewhat on its proximity to the fall line, and this bed of sand is underlain with a nearly or quite impervious stratum of compact grit and clay, which is also very thick.

The sand deposit absorbs the rain which falls on it with great rapidity, removing it from the action of the sun and wind and diminishing the evaporation to a great extent, while the great thickness of the mass enables it to store up a large amount of water and to give it out gradually as it sinks to and flows along the impervious stratum underlying the sand. The sand thus acts as a storage reservoir and regulates the flow of the streams of this region to a truly remarkable extent. Sand and gravel in general, though absorbing water with great rapidity, give it out with equal rapidity unless they occur in masses of sufficient size to store up a large amount of water without reaching the point of saturation, and as a consequence of this the regularity of the flow of the streams draining an area of sand will be somewhat in direct proportion to the thickness of the deposit. If the depth is great, then the flow of the streams draining the area will be regular and the run-off will be large in proportion to the rainfall, while if the depth is less, the flow will be less and less regular as the depth is diminished, and while the total run-off may be as great as in the first case, or greater, the distribution will be such as to render the useful amount much smaller.

The depth of the deposit of sand becomes less as the western limits of the belt are approached. Even above the limit of the sand-hill region, and up as far as the junction of Haw and Deep rivers, the typical formations of the coastal plain region predominate, the soils being sands and sandy clays, and the topography does not differ greatly from that of the sand-hill belt, except that the hills possibly rise to slightly greater heights and the slopes are steeper. The considerable differences in soil texture, however, cause very appreciable differences in flow between the streams of this portion of the basin and those of

the sand hills, the floods being much more sudden and violent, and the dry-weather flow much smaller per unit of area drained.

The area drained by the Haw, for a short distance above its junction with the Deep, is a region of sandstone and shale formations; but there is soon a change to metamorphosed slates and schists, and for a long distance the country near the river is rough, rugged, and broken, though it becomes somewhat smoother and more regular at considerable distances from the stream. Throughout this section the soil is thin, or in many places largely removed, exposing the bare rock in the hillsides, and as the slopes are steep the storm waters are shed into the streams with great rapidity, causing violent and destructive floods, which, however, are of short duration. The small depth of the soil affords space for only a very small amount of subterranean storage in the soil interstices, and in time of drought many of the minor streams cease flowing altogether, while the flow in many of the larger streams becomes nearly inappreciable.

Passing farther up this stream, however, the character of the basin changes again, the country rock becoming a granite. At the same time the character of the topography becomes less bold and rugged and the soil becomes deeper and more pervious. Therefore, throughout this portion of its course, the violence of the floods is not so great and the dry-weather flow is much larger per unit of area drained.

The statements made above relative to the area drained by the Haw apply with equal force to the area drained by the Deep; but a larger proportion of the basin of the Deep is in the slate region, and as a consequence its flow is even more variable than that of the Haw; the floods being more violent and the dry-weather flow smaller. Only a very small portion of this basin lies in the granite belt mentioned above. This portion is at the very source of the stream, and is entirely too small to exert any appreciable influence on the flow at points many miles below.

Gage heights of Cape Fear River have been taken at Fayetteville, N. C., since 1889. This station was established by the United States Weather Bureau, and maintained by it until 1895, when the United States Geological Survey began to make measurements of the river at this point. The Geological Survey has stations also on Rockfish Creek, near Brunt, and on Deep River at Cumnock. The description of these stations, the results for 1902 at the last two stations, and a complete recapitulation of the data collected at Fayetteville are given below:

CAPE FEAR RIVER AT FAYETTEVILLE, N. C.

This gaging station is at the bridge of the Atlantic Coast Line, about a mile east of Fayetteville, N. C. The Weather Bureau has a gage fastened on the lower side of the east abutment of the covered highway bridge, this being about 400 feet above the railroad bridge, from

which discharge measurements are made. The lower 29 feet of this gage consists of a rod divided into feet and tenths and firmly fastened to the abutment. Above the 29-foot mark the scale is painted on the rock. The observer is Frank Glover, who has charge of the steamboat landing just below the railroad bridge. For his convenience, he has placed a subsidiary gage at the steamboat landing reading about the same as the official gage, and from this observations are taken. The channel is straight and the current moderately swift and not influenced by dams or other obstructions. The banks are high and the total flow of the river is in one channel, even during the highest floods. The bed is fairly constant.

Discharge measurements of Cape Fear River at Fayetteville, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Second-feet.*
September 26	C. C. Babb	1.59	489
December 7	do	2.90	1,109
1896.			
April 5	E. W. Myers	19.30	10,525
April 25	do	4.00	1,618
May 22	do	4.00	1,322
June 8	do	10.00	5,041
June 8	do	9.20	4,207
July 11 [a]	do	49.10	51,115
September 2	do	1.10	519
September 19	A. P. Davis	1.88	770
1897.			
March 12	E. W. Myers	23.00	16,777
July 27	do	7.00	2,682
September 30	do	.70	424
1898.			
January 10	E. W. Myers	3.55	1,303
August 22	do	28.35	23,215
1899.			
February 7	E. W. Myers	46.50	61,921
May 24	do	6.40	3,142
June 6	do	4.20	1,577
October 13	do	6.00	2,132
November 29	do	9.65	7,742

[a] Inaccurate; disregarded.

Discharge measurements of Cape Fear River at Fayetteville, N. C.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
February 9	E. W. Myers	6.90	3,748
April 12	do	6.10	2,686
April 25	do	25.30	13,479
May 17	do	3.80	1,596
June 29	do	5.80	2,331
August 11	do	.70	415
November 3	do	.75	416
1901.			
April 5	E. Graves	47.60	46,519
July 15	E. W. Myers	40.30	38,300
November 29	J. S. Henderson	4.50	1,783
1902.			
May 8	J. S. Henderson	4.50	2,111
July 12	B. S. Drane	2.50	1,120
August 19	do	2.70	1,178
September 5	do	.50	446
October 16	do	5.13	2,487

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1889.												
1	10.00	18.00	15.00	8.70	12.00	10.00	40.60	33.50	14.00	5.50	8.50	14.00
2	11.00	15.00	13.00	8.40	10.00	40.00	42.60	44.20	13.10	6.00	7.40	10.20
3	10.00	13.00	11.00	8.10	8.50	30.00	43.90	37.50	9.20	5.60	6.90	8.10
4	9.00	12.20	9.00	7.80	7.50	22.00	41.40	28.00	8.60	5.20	6.80	7.50
5	25.00	10.70	7.20	7.50	7.00	15.00	37.40	33.50	8.10	4.50	7.20	7.20
6	38.00	10.40	5.80	7.20	6.60	9.50	33.00	38.00	7.50	4.40	7.40	7.10
7	35.00	10.20	5.70	6.90	6.30	8.00	28.40	37.00	7.10	4.20	6.90	7.00
8	31.00	10.10	5.60	6.60	6.20	6.80	20.00	33.00	7.50	4.60	6.80	6.80
9	26.00	10.00	5.50	6.30	6.10	6.00	12.00	24.00	9.50	4.70	6.60	6.70
10	20.00	10.00	5.40	6.00	6.00	5.00	7.00	18.00	8.30	5.00	7.80	6.40
11	17.00	9.80	5.30	5.80	5.80	6.00	6.80	20.00	7.80	4.00	7.90	6.30
12	14.00	9.60	5.30	5.60	5.50	7.00	9.00	16.00	6.80	3.80	7.50	6.00
13	11.00	9.50	5.20	5.40	5.00	6.50	10.40	14.00	6.30	3.70	7.20	5.80
14	9.00	9.40	18.00	5.30	4.50	6.00	10.00	10.10	6.10	3.50	7.60	5.70
15	8.00	10.00	21.00	10.00	4.00	5.80	9.50	10.00	6.00	3.40	7.90	5.60
16	8.00	15.00	16.00	15.00	3.80	6.00	9.00	12.00	6.50	3.30	7.20	5.40
17	15.00	25.00	14.00	20.00	3.50	5.70	8.20	12.20	6.90	3.20	6.90	5.00
18	30.00	34.50	10.00	18.00	3.40	6.00	7.50	10.00	7.30	3.20	8.20	4.90
19	28.00	40.00	13.00	16.00	3.30	7.00	15.40	7.50	7.00	3.20	9.50	4.70
20	30.00	43.00	12.00	12.00	3.20	8.50	11.00	6.90	6.90	3.10	10.20	4.60
21	35.00	42.00	11.70	9.00	3.20	8.00	9.00	6.40	6.00	3.10	16.20	4.40

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1889.												
22	30.00	38.00	11.50	7.00	3.20	7.50	8.50	6.20	6.00	3.10	19.90	4.40
23	25.00	34.00	11.30	6.00	3.10	8.00	8.20	6.00	5.80	3.00	24.00	4.40
24	20.00	36.00	11.00	5.00	3.10	7.50	8.00	6.50	5.70	3.00	29.00	4.30
25	16.00	31.00	10.80	5.50	3.00	7.00	9.00	7.00	5.60	4.00	32.00	4.30
26	22.00	25.00	10.60	12.00	3.00	6.00	20.00	8.00	5.50	5.50	27.20	4.30
27	38.00	20.00	10.20	18.00	2.90	5.00	33.50	11.00	10.00	13.00	19.10	4.20
28	34.00	17.00	10.00	20.00	2.90	5.50	43.00	21.00	9.00	21.50	21.00	4.20
29	27.00	.....	9.80	18.00	2.80	10.00	45.00	31.00	8.40	25.00	20.20	4.20
30	23.00	.....	9.40	15.00	2.80	38.00	43.00	28.00	7.90	20.00	17.00	4.10
31	19.00	.....	9.00	.....	3.60	.....	38.70	22.00	.....	15.00	.....	4.80
1890.												
1	7.20	4.60	22.00	7.70	6.00	6.40	2.90	1.10	16.50	8.00	7.80	5.80
2	7.50	4.80	23.10	7.60	5.80	6.00	2.80	1.60	13.40	7.60	7.60	5.90
3	7.40	5.00	20.00	7.80	5.70	5.50	3.10	4.20	10.20	7.00	7.40	6.40
4	7.00	5.70	17.40	8.00	7.60	4.00	4.50	5.10	7.10	6.50	7.00	5.10
5	6.50	5.90	16.20	7.80	9.40	3.60	6.20	4.90	5.20	6.20	8.40	4.90
6	6.20	6.20	11.40	7.70	12.00	3.10	5.70	4.80	4.80	6.00	9.20	4.70
7	5.80	7.50	9.30	7.60	14.60	2.90	5.00	5.60	4.60	5.80	9.00	4.60
8	5.70	8.20	9.10	7.50	12.00	3.90	4.70	10.20	4.50	5.60	8.40	4.80
9	5.40	10.00	9.00	7.40	10.10	6.70	3.90	14.40	4.20	5.20	8.00	5.20
10	5.00	14.80	8.80	7.30	9.20	10.00	2.80	18.10	4.00	4.00	7.80	6.70
11	4.90	12.20	8.60	7.20	8.90	11.00	2.60	22.00	5.90	3.90	7.70	6.40
12	4.80	11.00	8.20	7.80	8.70	9.80	2.30	24.50	6.20	3.80	7.50	6.00
13	4.70	10.20	7.40	8.20	8.50	8.60	1.90	20.10	6.00	3.50	8.40	5.80
14	4.60	10.00	7.20	8.30	8.20	7.40	1.60	15.20	7.10	4.00	8.90	5.60
15	4.50	9.20	8.40	8.00	7.90	6.80	1.40	10.60	14.80	3.80	8.70	5.10
16	4.30	10.40	12.20	7.80	7.80	6.40	1.20	8.40	27.90	3.70	8.50	5.00
17	4.20	11.20	14.10	8.40	7.60	6.20	2.20	8.20	30.20	4.80	8.40	4.90
18	4.00	10.10	12.20	10.20	7.50	6.80	2.50	9.40	21.40	5.90	8.00	6.20
19	4.00	9.00	10.10	12.00	7.00	6.70	2.80	13.50	16.20	13.40	7.80	10.10
20	4.20	8.20	8.90	14.50	6.70	6.60	2.90	17.60	11.00	15.00	7.40	20.20
21	4.20	7.80	10.20	12.40	6.00	6.40	2.70	21.40	8.00	11.20	7.00	18.00
22	4.20	7.50	12.10	10.20	5.70	6.00	2.60	20.10	6.10	8.90	6.50	14.10
23	4.10	8.60	14.40	9.10	4.00	5.50	5.20	17.20	5.20	8.00	6.10	12.20
24	4.20	11.00	16.80	8.80	3.70	5.10	7.10	15.10	4.90	10.20	5.70	10.10
25	4.20	12.00	23.20	8.50	3.50	4.80	10.20	18.40	4.80	12.40	5.00	9.80
26	4.10	14.20	20.00	8.20	5.40	4.70	9.10	18.00	5.20	22.80	4.70	12.40
27	4.10	19.00	16.40	7.90	9.20	4.10	8.20	13.20	6.80	18.10	4.50	18.20
28	4.20	20.00	12.10	7.40	12.40	3.80	12.40	10.40	7.20	12.40	4.20	14.10
29	4.20	.....	10.20	6.80	9.80	3.40	15.10	10.10	8.10	10.20	5.10	12.00
30	4.20	.....	8.10	6.20	7.20	3.00	18.20	8.40	8.40	8.40	5.20	10.20
31	4.20	.....	7.80	.....	6.80	.....	20.00	10.20	.....	8.00	.....	9.40
1891.												
1	9.00	12.40	10.20	16.40	6.20	31.40	4.70	10.50	26.10	4.50	3.50	13.10
2	8.50	15.60	12.40	14.10	6.00	22.00	5.30	19.10	17.20	4.40	3.80	12.40
3	8.00	14.20	14.00	17.20	5.80	16.20	6.40	31.40	14.40	5.20	3.70	10.00
4	7.70	13.10	16.20	19.10	5.40	10.20	6.00	29.20	13.70	5.30	3.60	8.10
5	7.20	12.00	19.10	20.00	5.00	9.50	5.10	25.00	12.80	4.90	3.50	7.30
6	7.00	11.40	17.40	18.00	5.80	10.40	6.40	20.60	10.10	4.80	3.90	7.00
7	7.40	10.00	15.20	16.40	6.40	12.20	8.20	17.00	12.40	4.60	3.80	6.80
8	7.80	12.40	12.10	13.60	7.00	14.50	15.10	16.10	13.60	6.20	3.40	7.40
9	8.00	18.20	11.20	12.20	6.80	16.20	13.20	11.20	14.80	7.80	3.20	8.00
10	10.20	17.00	14.40	11.00	6.40	14.30	11.70	10.10	14.00	7.20	3.60	7.70

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1891.												
11	16.40	16.10	16.10	10.10	5.50	12.00	8.20	9.00	11.80	6.80	4.20	7.50
12	21.20	14.20	22.10	12.40	5.00	13.40	7.10	8.40	10.20	6.60	4.70	7.30
13	18.00	12.10	34.20	15.70	4.70	14.50	6.40	7.20	9.10	5.90	4.40	7.00
14	14.10	11.00	41.00	12.00	6.80	10.20	5.20	6.90	8.40	5.70	4.00	6.80
15	12.20	10.20	36.20	10.20	9.40	8.10	6.10	7.00	8.00	7.10	3.80	7.90
16	10.10	10.00	29.40	11.40	12.20	6.50	6.80	6.20	7.60	9.20	3.60	8.60
17	9.40	9.50	21.00	12.00	12.00	6.20	6.00	5.30	6.90	8.00	4.10	8.40
18	10.20	8.10	16.60	11.20	10.20	6.80	5.80	5.10	5.40	7.70	4.90	8.00
19	14.20	8.00	14.40	10.10	9.40	7.40	5.60	7.20	6.00	7.20	4.80	7.80
20	16.40	9.20	16.80	9.40	8.10	7.90	5.20	8.40	5.20	6.80	4.70	7.40
21	14.10	14.10	21.70	8.20	7.60	7.00	6.10	8.00	5.00	6.40	4.40	7.00
22	12.20	39.20	18.90	10.70	7.00	6.50	7.70	17.90	4.90	6.00	4.00	6.80
23	13.10	37.40	17.10	10.90	6.50	8.20	10.40	32.40	4.70	5.50	3.80	6.70
24	18.40	30.10	16.20	9.10	6.10	8.00	11.10	43.10	5.00	5.00	4.20	7.80
25	19.60	19.20	18.40	9.00	5.20	7.20	12.90	40.20	4.90	4.80	5.10	8.00
26	18.00	16.00	20.00	8.70	10.40	6.90	13.00	39.00	4.80	4.20	4.40	7.40
27	16.20	14.40	26.40	7.10	25.90	6.00	12.50	35.20	4.90	4.00	4.70	7.10
28	14.10	12.00	30.00	7.00	35.70	5.40	10.10	24.60	5.10	3.80	3.90	6.80
29	12.40	.....	25.80	6.80	40.20	4.10	8.90	30.10	4.80	3.70	6.20	6.60
30	10.60	.....	20.10	6.40	45.10	4.20	8.40	31.40	4.60	3.90	10.20	7.50
31	10.00	.....	18.20	.....	39.20	.....	9.60	32.20	.....	3.60	.....	8.10
1892.												
1	8.80	9.90	26.20	8.00	7.40	7.40	12.10	5.40	5.80	2.60	1.00	2.00
2	7.50	9.40	21.40	7.80	7.00	8.10	14.20	5.80	5.10	2.50	.90	1.80
3	7.00	9.00	18.10	9.40	6.80	8.40	11.60	5.50	4.20	2.30	.80	1.70
4	7.60	8.80	14.20	10.20	6.70	9.60	10.10	5.20	3.70	2.10	1.40	2.00
5	8.00	8.70	11.60	10.00	6.50	10.40	14.40	5.10	3.00	1.90	1.60	2.10
6	9.40	9.40	10.40	9.40	6.40	14.60	15.00	5.00	2.70	1.70	1.70	2.20
7	9.00	9.20	9.20	13.80	6.20	14.00	17.40	4.90	2.40	1.50	1.90	2.40
8	8.60	9.00	10.40	21.40	6.10	10.40	16.30	4.70	2.00	1.30	2.00	2.00
9	7.50	8.80	11.00	34.20	6.00	12.60	14.10	4.50	1.80	1.10	2.50	1.90
10	8.80	8.40	9.80	33.10	5.80	14.10	11.60	4.10	1.70	1.00	4.10	2.50
11	8.70	8.20	9.40	20.50	7.20	11.40	9.40	3.90	1.50	1.40	5.40	2.70
12	8.90	9.40	8.70	17.10	7.90	10.20	7.20	3.80	1.20	1.60	4.50	2.60
13	9.40	9.10	8.20	14.20	8.20	8.40	8.60	3.20	1.00	1.50	4.00	2.40
14	12.00	8.70	7.80	12.70	7.80	7.00	11.40	2.80	.90	1.40	3.70	2.30
15	13.60	8.40	7.00	12.00	7.60	6.60	12.70	2.40	2.50	1.30	3.40	2.10
16	18.50	7.90	6.80	15.20	7.00	6.00	13.10	1.90	5.50	1.20	3.80	2.20
17	22.00	7.70	8.20	13.60	7.40	5.80	17.20	1.60	3.60	1.10	7.50	2.70
18	30.20	7.50	10.10	12.00	7.90	4.90	14.10	1.40	2.40	1.00	8.00	3.00
19	29.10	7.20	9.60	10.80	7.40	5.10	10.40	1.20	1.80	1.10	7.30	3.30
20	37.80	8.40	9.20	11.10	6.80	7.20	7.70	1.00	1.60	1.20	6.80	9.60
21	49.50	8.80	8.70	10.40	7.60	9.40	6.90	.90	1.80	1.10	6.30	12.00
22	47.20	8.00	8.10	10.00	7.90	11.20	6.70	.80	4.90	1.00	5.00	14.40
23	36.40	7.60	7.80	17.20	10.80	12.60	7.00	1.70	7.40	.90	4.10	13.10
24	28.10	7.40	7.40	19.50	14.40	10.00	6.80	2.30	6.10	.80	3.50	10.70
25	22.30	7.00	8.80	14.10	12.00	9.40	7.20	3.80	5.30	.90	3.00	8.20
26	17.40	8.40	10.60	12.70	10.60	10.20	7.00	5.70	4.90	1.00	2.90	6.00
27	15.10	10.20	17.10	10.60	8.10	12.40	5.40	6.10	4.60	1.20	2.60	4.90
28	13.70	17.40	14.20	8.40	7.40	16.20	4.90	5.20	4.00	1.30	2.50	4.40
29	12.00	24.60	10.00	8.10	6.80	20.00	4.60	3.80	3.40	1.40	2.30	4.00
30	11.80	.....	9.10	7.80	6.20	18.70	4.40	4.90	2.70	1.20	2.10	3.90
31	10.20	.....	8.20	.....	6.00	.....	4.00	4.60	.....	1.10	.....	3.80

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1893.												
1	3.00	19.60	12.90	5.10	4.50	7.80	3.80	1.80	22.80	6.10	7.00	9.00
2	12.00	14.30	20.80	4.80	5.00	5.00	5.60	3.70	27.40	5.70	6.80	7.00
3	20.50	10.80	17.20	4.50	7.00	6.20	4.90	6.90	32.30	5.00	6.50	6.30
4	16.50	8.40	14.80	4.40	15.00	8.00	4.10	7.00	30.00	5.30	6.10	5.90
5	13.00	7.50	13.40	4.80	31.50	6.60	4.80	6.80	20.80	5.10	6.00	15.90
6	10.00	6.60	12.40	6.20	29.00	6.00	5.20	10.00	14.00	9.00	5.80	15.60
7	8.00	6.70	11.10	6.40	19.90	7.00	4.80	7.30	8.60	8.00	5.80	15.00
8	6.10	9.50	10.00	5.80	17.90	14.00	3.60	6.40	6.00	6.00	5.70	15.40
9	5.40	11.40	9.40	5.30	14.20	23.70	2.80	4.80	4.80	5.10	5.90	14.00
10	5.00	10.00	8.60	5.00	8.00	14.10	3.20	3.50	4.70	4.90	5.90	13.50
11	4.10	12.60	8.90	4.40	7.90	7.00	2.50	2.60	5.50	4.10	5.30	12.90
12	4.50	24.80	8.10	4.10	7.70	6.40	2.00	2.10	12.50	3.70	6.10	11.50
13	4.60	35.60	7.20	4.10	6.50	5.70	1.70	1.80	16.00	3.60	6.00	9.20
14	4.40	41.00	7.10	4.70	6.00	4.10	1.60	1.60	39.00	13.60	6.30	8.40
15	4.50	42.30	7.00	7.00	5.40	5.70	1.40	1.40	35.00	23.00	6.20	7.30
16	4.00	38.60	6.60	7.90	5.50	8.10	1.40	1.30	29.00	20.60	6.00	7.00
17	3.70	40.20	6.20	7.20	5.60	7.00	1.30	1.20	23.00	14.20	5.80	16.00
18	3.20	37.40	6.10	5.70	7.00	15.00	1.40	1.20	15.60	11.20	5.60	26.00
19	3.00	35.10	6.50	5.50	5.00	13.70	1.40	1.60	8.00	8.00	5.30	22.50
20	4.30	30.00	6.70	4.70	4.20	10.20	3.90	6.70	5.30	5.80	5.00	17.30
21	4.70	24.30	6.80	5.00	3.90	8.40	2.50	4.40	4.20	5.60	4.90	14.80
22	4.80	19.90	6.90	5.20	3.80	6.40	2.40	2.70	4.60	6.00	4.70	10.70
23	4.70	15.60	7.00	4.80	3.60	5.60	2.00	1.90	4.20	33.50	4.60	9.00
24	4.40	13.00	6.50	4.30	3.30	6.00	1.40	1.80	4.00	42.00	5.10	8.00
25	4.30	12.20	6.50	4.00	3.20	9.50	1.30	7.80	4.10	39.00	5.00	7.70
26	4.60	9.80	6.90	3.90	3.00	6.40	1.20	5.90	3.80	31.00	4.90	7.00
27	5.60	8.00	7.70	3.70	4.20	5.00	1.10	3.80	3.60	23.40	4.50	6.20
28	7.40	8.50	7.40	4.00	4.10	4.00	1.10	3.60	4.40	17.20	4.90	6.20
29	15.50	.....	7.20	5.00	3.80	2.70	1.50	5.60	6.70	14.20	8.60	5.90
30	19.00	.....	5.80	5.60	4.20	3.50	1.20	22.90	6.90	12.00	12.90	5.80
31	23.60	.....	5.20	.....	8.60	.....	1.20	25.90	.....	8.80	.....	6.00
1894.												
1	8.00	15.90	25.00	5.70	3.40	7.20	2.10	6.00	5.00	14.30	12.60	4.30
2	9.30	11.60	28.20	5.40	3.40	5.30	2.10	7.00	4.30	12.90	12.00	4.30
3	7.30	10.60	26.50	5.00	3.30	4.00	5.00	5.50	3.90	9.40	10.00	4.40
4	7.00	9.70	22.00	4.90	3.30	3.60	7.70	14.00	3.40	7.20	14.20	4.10
5	6.00	12.80	18.00	5.00	3.20	3.10	7.60	25.40	4.20	6.60	20.00	4.40
6	6.10	15.00	16.10	5.80	3.40	2.60	5.80	31.20	4.60	11.30	15.90	5.10
7	6.40	12.00	12.80	4.80	10.60	2.50	4.50	34.40	4.00	9.70	11.50	5.40
8	23.00	10.90	10.00	4.60	9.80	2.30	3.90	29.60	3.80	7.00	8.70	5.50
9	27.00	8.60	8.30	4.40	7.50	2.00	3.80	24.70	3.60	6.00	7.00	5.60
10	23.50	12.00	8.30	4.10	5.40	2.10	3.10	19.00	3.40	29.00	6.20	5.70
11	25.60	10.20	8.30	4.20	4.80	2.00	2.60	12.20	3.10	47.40	6.50	5.80
12	23.50	8.60	8.00	8.30	4.40	2.00	2.50	9.00	2.60	47.90	6.20	10.20
13	19.50	8.20	7.80	8.60	3.30	1.90	2.00	7.60	2.30	38.80	6.20	17.20
14	17.00	8.00	7.30	7.00	3.20	1.60	1.80	8.80	1.90	29.00	6.30	18.40
15	15.40	13.60	7.30	6.20	3.60	1.60	1.60	8.10	1.90	22.30	6.50	12.00
16	14.40	27.40	7.00	5.00	3.40	1.50	1.60	8.40	1.80	16.60	7.10	10.40
17	12.00	28.00	6.90	4.70	4.20	1.20	1.80	10.40	1.50	12.40	6.20	8.00
18	11.60	23.80	6.30	4.30	4.00	1.10	2.10	10.30	1.40	8.60	6.90	7.20
19	11.00	18.60	8.60	4.20	4.50	1.00	3.30	9.00	4.60	7.20	6.40	6.50
20	10.00	16.00	9.70	4.00	6.80	1.30	2.90	7.80	12.00	5.80	5.90	6.00
21	8.20	15.00	8.50	5.60	10.00	2.90	2.70	8.60	8.90	6.20	5.90	5.90

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1894.												
22	7.30	12.40	7.00	5.80	8.00	3.00	2.30	6.70	7.00	5.80	6.00	5.30
23	7.00	11.00	6.90	5.80	6.40	2.70	4.30	5.60	5.20	5.60	5.70	5.50
24	6.80	11.00	6.30	5.30	7.20	2.80	8.00	5.00	4.20	5.50	5.40	5.10
25	7.00	11.20	6.00	5.00	8.40	2.80	14.20	4.70	3.30	5.40	5.40	5.00
26	7.00	12.00	6.90	4.20	8.20	2.20	11.00	3.60	2.90	5.30	5.60	4.90
27	6.80	14.40	8.60	4.00	7.00	1.80	7.70	5.30	4.00	5.50	5.20	4.90
28	6.60	20.00	8.00	3.70	4.90	1.80	4.60	9.40	11.60	10.50	5.00	8.50
29	7.00	.....	7.00	3.70	4.80	1.70	3.90	11.00	17.00	15.60	4.90	11.60
30	11.40	.....	6.50	3.50	4.30	1.70	3.30	7.00	15.50	13.20	4.60	8.90
31	17.00	.....	6.00	.....	4.60	.....	4.50	5.90	.....	10.40	.....	7.00
1895.												
1	6.00	28.00	10.20	9.00	44.60	6.00	10.30	4.80	5.00	1.20	4.20	3.60
2	6.00	25.00	9.80	8.40	40.80	5.20	11.20	4.80	4.30	1.10	5.00	3.10
3	6.00	28.00	12.00	10.90	33.60	4.10	15.50	4.10	4.40	1.00	6.00	3.20
4	6.40	27.80	24.80	11.00	27.00	4.00	14.00	3.80	4.40	1.00	7.00	3.00
5	7.80	23.40	25.20	11.00	22.00	4.00	11.50	3.60	4.00	.70	6.00	3.00
6	7.40	18.90	19.20	9.40	17.90	4.20	8.00	3.40	3.70	.90	4.80	3.00
7	6.10	15.20	17.00	9.00	14.20	4.00	6.50	3.10	3.40	1.10	4.10	2.90
8	5.90	14.00	15.40	11.50	17.20	4.50	5.40	3.70	3.20	1.30	3.60	2.80
9	8.00	11.80	23.60	42.00	18.00	4.40	5.00	3.90	3.20	1.60	3.20	2.60
10	37.00	11.00	20.00	47.70	14.80	4.30	5.10	4.70	4.70	1.90	3.10	3.90
11	52.00	10.00	18.70	46.40	11.80	4.10	5.00	4.40	5.00	1.70	3.70	10.60
12	58.00	9.80	17.80	35.00	12.40	5.30	4.90	4.00	4.70	1.60	7.00	13.20
13	56.40	9.40	20.60	25.20	11.20	7.00	5.40	4.30	4.50	2.00	8.90	10.00
14	47.40	9.00	23.00	18.50	10.90	9.40	5.40	8.00	3.90	2.00	6.60	8.20
15	38.00	8.80	30.40	14.20	9.00	8.40	4.40	7.00	3.10	1.80	5.40	6.20
16	25.50	9.20	26.50	11.80	8.50	10.20	5.50	7.20	2.80	1.60	4.40	5.20
17	17.80	10.50	24.00	12.40	8.40	11.00	5.70	12.90	2.80	1.50	4.00	4.70
18	14.80	11.60	20.20	29.20	8.00	12.20	5.80	20.00	2.60	1.30	3.80	4.30
19	12.00	14.00	18.00	36.70	11.80	8.90	7.00	20.20	2.40	1.50	3.50	4.10
20	11.00	16.20	14.80	32.50	10.40	5.80	5.20	15.30	2.10	1.50	3.20	4.20
21	10.40	16.40	31.00	26.50	12.00	4.80	4.50	11.50	2.10	1.20	3.10	4.00
22	9.90	18.40	41.00	18.00	8.40	4.20	4.20	8.90	2.00	1.30	3.10	4.00
23	11.00	18.90	37.10	14.00	7.80	5.20	4.90	8.00	1.70	1.40	3.00	18.50
24	10.40	19.00	30.10	12.90	7.20	5.60	5.00	8.30	1.70	1.30	2.90	13.40
25	9.70	16.40	23.40	12.20	8.00	4.50	5.70	6.80	1.60	1.30	2.80	9.20
26	11.00	15.20	18.20	10.20	8.70	4.50	15.60	5.70	1.50	1.10	2.80	7.00
27	29.00	12.00	15.00	12.00	10.80	7.20	21.00	4.80	1.40	1.30	3.00	5.80
28	24.20	11.20	12.80	18.50	10.20	9.10	15.50	5.60	1.30	1.20	4.50	5.00
29	20.20	.....	10.20	28.00	9.50	10.20	10.00	7.00	1.30	1.40	4.00	4.90
30	24.00	.....	9.90	39.30	8.00	9.20	6.20	6.40	1.30	1.30	4.00	4.80
31	26.40	.....	9.40	.....	7.10	.....	5.10	6.10	.....	1.60	.....	6.00
1896.												
1	18.00	6.50	9.00	7.50	3.70	4.00	7.00	3.30	1.30	31.00	2.50	6.00
2	18.90	6.50	10.40	9.50	5.00	3.20	5.30	4.30	1.10	26.80	2.70	15.40
3	11.40	7.90	9.30	22.50	8.00	2.70	4.00	4.00	1.00	19.50	2.70	14.00
4	8.00	27.70	7.60	19.40	12.80	4.00	3.50	3.30	.80	12.90	3.00	12.40
5	6.50	31.00	6.80	13.00	10.40	19.00	3.50	3.00	1.50	7.80	4.30	10.40
6	5.70	30.00	6.00	9.80	8.30	20.00	5.90	3.00	3.00	4.90	17.00	9.50
7	4.60	45.40	5.80	8.00	6.00	14.00	4.40	2.80	8.50	4.20	19.00	9.60
8	4.40	48.00	5.80	6.80	4.50	10.00	15.00	2.60	9.50	3.60	14.30	13.50
9	4.60	45.00	5.40	6.00	4.40	8.00	34.80	2.30	5.50	3.20	10.40	14.50
10	4.60	42.40	5.40	5.40	3.90	6.20	47.50	2.00	4.00	3.00	7.70	13.60

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896.												
11	4.70	36.00	5.50	5.20	3.50	6.00	49.50	2.00	3.30	2.70	6.00	11.70
12	4.40	30.40	7.80	5.50	3.20	6.00	47.00	1.90	2.50	2.70	4.80	9.50
13	4.20	19.00	11.00	5.50	2.80	5.00	41.00	2.70	2.00	2.70	4.60	8.20
14	4.00	16.20	10.00	5.00	2.80	7.00	30 30	4.00	1.50	3.00	4.50	7.00
15	4.10	17.40	8.60	4.90	2.60	10.90	19.00	3.40	1.40	3.30	4.50	7.50
16	4.00	16.00	7.20	5.00	2.50	8.50	14.40	3.70	1.20	3.20	4.80	9.40
17	5.00	13.40	7.50	4.90	2.50	5.70	9.50	3.70	1.00	3.00	4.20	14.00
18	19.00	11.60	8.00	4.70	2.10	4.60	9.30	3.00	1.50	2.90	4.00	12.30
19	26.00	10.50	7.80	4.50	2.40	6.00	9.00	2.60	1.90	2.60	4.00	9.00
20	21.40	10.60	8.50	4.20	2.30	5.30	8.70	2.50	3.00	2.40	3.80	9.00
21	15.00	9.80	10.50	4.00	3.50	6.40	8.90	2.50	2.50	2.10	3.60	8.20
22	12.20	9.00	9.60	3.80	4.10	5.00	8.30	2.10	1.50	2.20	3.50	7.00
23	10.00	8.00	7.80	3.60	8.17	4.30	7.90	2.70	6.00	2.30	3.20	6.90
24	25.00	7.80	6 80	3.50	11.40	4.50	7.20	2.00	6.80	2.70	3.10	6.30
25	25.60	7.80	6.50	4.00	17.40	6.40	7.50	2.40	5.00	4.40	3.00	5.40
26	21.00	7.70	6.60	4.60	12.00	7.80	7.00	4.00	3.90	4.10	3.00	4.60
27	16.20	7.40	7.00	7.00	9.50	8.60	5.20	3.70	3.20	3.50	3.00	5.00
28	12.00	7.30	6.30	5.50	8.00	6.00	4.30	2.70	2.90	3 00	3.30	4.90
29	9.40	7.90	6.20	4.90	7.20	10.80	3.70	2.00	3.50	2.80	3.20	4.80
30	8.10	.....	5.80	4.10	6.00	8.90	3.60	1.90	8.00	2.50	3.50	4.90
31	7.00	.....	5.30	.....	5.00	.....	3.40	1.40	.....	2.50	.....	5.00
1897.												
1	6.20	5.50	13.40	7.70	6.10	7.00	5.00	4.70	2.20	0.70	1.90	5.50
2	6.00	5.90	11.70	8.00	10.00	8.60	3.20	3.20	4.60	.70	5.50	6.00
3	5.50	25.00	10.20	7.30	14.40	6.50	2.50	3.00	3.50	.80	9.70	5.10
4	5.50	27.00	9.00	8.00	13.20	5.00	2.00	2.70	3.00	.60	9.30	4.60
5	5.30	19.70	8.50	9.30	9.30	4.20	1.90	2.20	2.50	.70	7.20	4.30
6	5.00	15.00	7.60	27.00	8.00	4.30	3.90	2.60	2.10	.50	5.00	5.10
7	4.80	29.10	9.20	28.30	6.30	7.00	4.20	4.10	1.80	.30	4.00	5.20
8	4.60	36.50	25.60	22.00	5.60	5.50	4.80	6.80	1.50	.20	3.50	4.70
9	4.60	32.00	26.20	15.40	5.00	7.00	4.20	6.20	1.10	.20	2.90	4.10
10	4.40	24.30	20.00	23.50	4.60	7.80	4.00	6.20	1.10	.30	2.60	3.70
11	4.20	17.60	21.40	28.00	4.20	5.50	4.00	5.40	1.10	.60	2.40	3.40
12	4.10	13.00	22.00	22.70	5.20	4.40	3.90	4.30	1.10	.60	2.50	3.30
13	4.00	18.20	29.70	18.30	6.00	4.20	6.00	3.50	.90	.60	2.40	3.30
14	4.50	19.00	32.00	14.30	10.00	3.50	11.10	3.00	.80	.60	2.30	3.00
15	6.00	16.30	36.40	12.80	17.40	3.20	6.00	2.40	.70	.40	2.00	3.00
16	6.40	12.80	37.60	10.20	14.00	3.00	4.60	3.80	.60	.30	2.00	4.00
17	7.80	13.20	37.60	10.00	10.30	2.70	3.20	3.00	30	.30	1.80	4.90
18	7.00	15.00	29.00	9.80	8.30	3.00	3.20	2.50	80	.30	1.60	5.20
19	8.50	12.90	23.80	8.40	6.70	3.50	3.80	2.20	.80	.30	1.90	4.50
20	9.60	10.80	19.20	7.70	5.50	4.50	5.50	3.00	.90	.40	1.90	3.90
21	7.80	14.00	18.00	7.00	4.80	4.30	16.50	3.20	1.40	.90	1.70	3.50
22	20.40	24.30	16.60	6.70	4.50	3.50	25.30	5.00	1.40	1.50	1.70	3.50
23	24.55	23.50	13.70	6.30	4.30	3.00	16.40	5.20	1.10	1.60	1.70	4.80
24	16.80	23.50	11.20	5.80	4.20	2.40	12.70	6.50	1.10	1.70	1.50	9.00
25	12.60	24.20	10.00	5.50	4.30	1.80	8.50	5.60	1.10	2.00	1.40	7.80
26	8.50	23.30	9.30	5.50	4.60	4.80	6.10	4.90	1.10	2.20	1.60	5 70
27	7.20	20.40	8.40	5.20	4.50	3.40	7.00	4.00	.90	1.90	1.70	6.00
28	7.00	16.60	8.00	4.70	4.40	2.80	7.30	3.50	1.10	1.90	1.90	10.00
29	6.60	.....	7.40	4.50	4.00	3.70	6.90	2.90	.80	1.70	2.30	9.50
30	5.90	.....	7.20	4.40	4.40	4.00	5.60	2.50	.70	1.90	3.50	7.10
31	5.60	.....	7.20	.....	4.30	.....	5.00	2.50	.....	1.70	.....	5.00

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898.												
1	5.00	5.00	3.50	21.00	6.60	3.20	2.00	6.00	10.30	2.90	14.00	6.10
2	4.90	4.90	3.20	17.30	5.50	3.00	2.00	7.00	9.60	2.50	9.30	6.90
3	4.50	4.80	3.50	11.00	5.00	3.00	1.50	7.00	7.20	2.40	7.10	6.70
4	4.30	4.40	3.50	9.40	4.30	2.70	1.20	6.40	5.70	2.50	5.50	8.40
5	3.70	4.00	7.00	6.00	4.10	2.30	1.00	5.20	14.00	2.40	4.70	16.00
6	3.70	3.90	20.50	12.80	3.80	1.90	5.10	5.00	18.80	2.50	4.20	18.00
7	3.60	3.80	17.70	21.50	3.10	1.40	12.00	4.10	14.00	5.50	3.80	14.60
8	4.00	3.60	11.00	15.30	8.00	1.20	16.20	3.00	12.50	5.60	5.40	11.80
9	3.60	3.50	8.70	11.70	7.00	1.10	12.40	3.00	13.20	4.20	5.00	9.00
10	3.50	3.40	7.90	8.00	6.30	1.20	10.20	2.60	10.00	3.40	4.80	7.00
11	3.40	3.40	5.80	7.00	5.40	1.10	12.50	2.30	8.70	2.70	4.30	5.50
12	3.30	3.50	5.20	6.10	4.50	1.10	8.00	3.70	6.50	2.30	3.70	5.30
13	3.40	3.50	4.90	5.90	4.00	1.20	6.00	5.00	5.00	2.00	3.50	5.30
14	3.60	3.40	5.00	5.70	3.70	1.30	5.10	9.40	4.30	1.90	3.90	5.30
15	3.80	3.20	5.10	5.40	5.00	1.30	5.10	16.00	4.10	1.80	4.30	5.00
16	3.60	2.90	8.00	5.40	4.90	2.50	5.50	14.00	3.80	1.80	6.00	5.00
17	3.70	2.90	9.20	5.60	5.10	3.90	5.50	10.00	3.60	1.50	7.00	4.80
18	3.60	2.90	7.70	5.40	4.70	4.30	4.10	7.00	3.40	1.30	9.80	4.60
19	3.70	3.10	6.20	4.70	4.20	3.90	6.00	9.20	3.10	2.00	10.20	4.70
20	3.80	4.50	5.50	4.40	4.00	4.00	5.50	22.20	2.90	5.00	11.00	4.60
21	3.60	5.30	5.00	4.20	3.50	7.00	5.50	29.00	2.50	5.00	12.20	5.30
22	4.10	5.70	5.00	4.00	3.00	7.00	4.20	29.20	2.20	4.50	9.60	6.10
23	4.40	6.00	4.70	3.90	3.00	5.50	3.60	23.50	2.50	10.00	7.80	8.00
24	4.40	5.50	4.50	4.10	2.90	4.30	10.00	18.00	15.00	9.80	5.60	7.30
25	4.40	5.10	4.20	4.40	12.00	3.20	7.00	10.30	14.00	6.00	5.10	7.00
26	5.50	4.50	5.00	7.20	11.40	2.70	6.00	6.00	9.80	4.50	5.00	6.40
27	14.00	4.10	6.00	10.40	9.00	2.20	4.60	6.10	7.00	4.70	5.10	5.50
28	11.00	3.80	5.60	10.70	6.70	1.70	4.10	6.20	5.00	4.50	4.70	5.30
29	9.20	.....	4.70	12.00	5.00	1.60	4.00	7.00	3.90	3.60	4.40	5.10
30	6.50	.....	4.30	9.60	4.00	2.10	3.90	8.50	3.40	3.50	4.70	4.90
31	5.30	.....	14.80	.....	3.50	.....	4.00	11.00	.....	10.00	.....	4.70
1899.												
1	4.50	11.00	30.80	17.80	7.20	6.00	2.90	11.50	2.40	2.00	11.00	8.00
2	4.60	18.10	25.00	17.00	6.00	6.40	6.40	10.00	2.20	1.70	21.40	6.40
3	6.50	14.00	21.00	14.00	6.00	8.00	8.00	8.80	1.90	1.70	17.50	6.50
4	6.50	12.80	28.60	12.20	5.50	7.60	7.60	7.00	1.60	1.50	12.80	7.00
5	5.80	23.00	34.40	15.60	5.50	6.10	6.10	5.50	1.50	1.40	10.40	6.70
6	5.50	31.90	33.20	21.00	5.50	4.20	4.20	4.20	1.60	2.10	8.30	5.50
7	5.50	41.00	27.40	17.60	5.50	4.20	4.20	3.20	1.40	14.40	6.50	5.10
8	17.00	50.80	25.00	23.20	8.60	3.80	3.80	2.60	2.00	13.50	5.00	4.90
9	21.40	52.00	20.00	35.50	14.20	3.50	8.30	7.00	1.80	17.00	5.00	4.70
10	14.90	47.30	15.00	30.30	13.00	4.50	9.30	10.20	1.90	13.20	5.00	4.30
11	10.20	37.40	11.50	23.00	9.80	7.50	6.40	7.00	1.80	10.00	4.80	4.30
12	8.00	30.00	10.20	19.40	10.90	8.10	5.00	5.50	5.70	7.00	4.50	4.50
13	9.30	20.80	9.40	15.80	11.00	10.00	3.60	4.60	4.00	5.00	4.60	4.00
14	10.00	12.30	8.70	13.50	15.40	11.10	3.10	3.70	4.00	4.50	4.30	14.00
15	19.00	10.00	18.50	10.20	17.30	8.00	2.60	3.00	4.60	3.80	4.00	10.00
16	23.60	12.50	38.60	9.80	12.00	5.80	2.40	2.70	4.00	3.50	4.00	7.50
17	17.20	24.00	42.00	9.00	9.70	5.00	2.40	2.50	2.50	3.50	4.00	6.00
18	14.50	36.50	38.00	10.00	7.20	4.60	4.50	2.40	1.80	3.00	3.90	5.40
19	13.40	42.60	28.00	9.20	5.50	4.10	4.00	2.70	1.60	3.30	3.80	5.00
20	11.00	43.00	28.80	9.40	5.30	3.70	3.50	2.70	1.80	3.00	3.60	4.80
21	9.20	38.50	32.00	9.00	5.20	3.20	3.00	2.30	2.50	2.70	3.50	4.50

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1899.												
22	8.00	34.00	25.00	8.50	5.00	3.20	2.40	2.20	4.00	2.50	3.30	4.00
23	7.00	28.30	18.00	8.40	5.30	3.00	2.30	5.00	3.70	2.20	3.30	4.20
24	6.20	23.00	14.70	8.00	6.30	3.10	2.80	3.70	3.20	2.30	3.80	5.40
25	6.20	18.20	12.00	6.60	6.00	2.90	4.00	2.50	2.60	2.10	4.00	10.00
26	6.00	16.40	10.00	7.00	5.50	2.50	6.40	2.70	2.90	2.10	4.00	12.00
27	7.00	17.00	10.00	10.00	5.30	2.80	7.00	2.10	3.70	2.10	4.50	9.70
28	6.80	28.40	12.00	11.40	4.70	3.10	12.80	1.60	3.90	2.10	5.60	7.30
29	6.60	.....	17.80	10.00	4.20	3.50	11.70	1.60	3.00	2.10	10.00	6.00
30	6.60	.....	21.70	8.80	4.20	3.20	9.90	1.50	2.50	2.10	9.50	5.90
31	7.00	.....	19.20	.....	5.00	.....	7.60	2.90	.....	4.20	.....	.....
1900.												
1	5.00	5.20	12.00	9.00	8.30	3.20	5.00	2.60	5.00	0.90	0.60	2.80
2	4.90	5.00	27.00	7.70	9.70	3.20	4.30	2.80	4.50	.80	.50	2.20
3	4.30	4.60	33.70	6.90	7.30	3.00	4.00	2.20	3.80	.70	.70	2.10
4	4.40	4.40	29.00	6.70	6.90	2.80	3.50	1.80	2.50	.60	2.50	2.30
5	4.20	5.30	22.30	9.10	6.40	2.80	3.10	1.80	1.80	.90	12.50	14.00
6	4.40	7.50	15.00	10.00	5.60	2.70	3.60	1.40	1.20	1.20	10.50	15.00
7	4.20	10.00	11.70	9.20	5.30	2.70	3.10	1.40	.80	1.00	7.00	9.20
8	4.10	8.00	9.70	6.70	5.00	2.60	3.10	1.20	.70	.80	5.20	8.40
9	3.90	6.40	10.00	6.00	5.00	3.50	2.60	.90	.60	.70	4.00	6.50
10	3.90	7.00	23.00	5.80	4.90	3.90	2.20	.80	.40	.70	3.40	4.80
11	4.80	10.00	19.00	5.80	5.50	4.20	1.80	.70	.60	.90	2.90	4.00
12	9.00	20.80	17.20	5.60	5.50	4.20	1.60	.70	.50	.80	2.50	3.50
13	21.30	25.70	14.30	18.00	5.00	3.00	1.40	.70	.30	1.80	2.40	3.40
14	21.00	36.00	10.40	18.00	4.70	2.60	1.80	.70	.40	1.60	2.00	3.30
15	17.30	35.80	8.70	14.40	4.00	2.50	5.00	.80	.50	1.30	1.90	3.30
16	12.00	30.00	9.80	10.20	3.80	3.00	3.00	.60	2.10	1.40	2.00	3.40
17	9.10	24.70	19.00	7.00	3.80	2.70	2.50	.50	10.40	2.90	1.80	3.10
18	7.50	18.40	19.00	6.00	3.60	5.50	2.00	4.50	8.40	2.70	1.50	3.00
19	6.50	13.70	15.00	6.00	8.00	14.00	1.70	3.90	4.60	1.90	1.30	3.00
20	7.70	9.00	12.40	38.00	18.00	8.00	1.50	2.80	3.20	1.60	1.10	2.60
21	12.50	8.20	10.00	44.00	14.00	5.70	1.30	2.40	2.10	1.20	1.00	4.00
22	14.00	9.10	9.40	44.00	10.40	4.40	1.10	1.70	1.70	1.00	1.10	12.80
23	11.70	23.00	8.50	38.00	7.00	4.00	1.00	1.60	1.40	.90	1.10	16.00
24	8.00	23.00	7.60	33.00	5.40	12.00	.90	3.50	1.30	.80	1.10	11.40
25	7.10	17.50	7.00	26.00	5.70	17.40	3.50	2.20	1.00	.80	1.10	9.80
26	6.50	21.00	9.80	22.00	5.50	16.00	3.80	2.30	.90	.70	1.50	7.00
27	6.10	19.00	14.00	17.00	5.50	13.70	4.50	1.70	.80	.70	1.50	5.60
28	5.60	14.10	14.00	12.20	5.00	8.00	12.00	1.20	1.30	.80	2.50	4.40
29	5.70	.....	11.60	10.00	4.50	5.50	9.00	.90	1.00	.60	3.20	4.00
30	5.50	.....	9.80	8.30	4.00	5.00	5.80	.90	1.10	.70	3.10	4.40
31	5.30	.....	9.60	.....	3.70	.....	4.60	1.10	.....	.70	.....	6.20
1901.												
1	12.00	6.40	4.20	12.80	5.20	13.30	9.20	4.70	11.00	10.40	3.60	3.80
2	11.40	6.40	4.00	9.60	4.80	10.00	10.00	4.90	13.60	9.30	3.80	3.70
3	10.00	5.50	3.90	14.40	4.50	9.00	9.50	4.20	12.40	10.00	3.80	3.60
4	8.20	5.60	3.70	45.90	4.50	7.80	7.00	4.00	9.80	9.40	3.60	4.00
5	6.00	9.00	3.70	47.70	4.30	6.30	5.50	3.60	7.60	8.50	3.60	4.00
6	5.70	11 00	3.70	41.70	4.00	6.30	4.60	6.00	6.50	7.50	3.60	3.80
7	5.20	8.20	3.30	30.80	3.90	6.00	3.80	29.40	5.80	6.30	3.70	4.10
8	4.60	6.40	3.10	23.80	4.00	5.90	4.10	43.60	5.50	5.90	3.70	4.00
9	4.00	6.00	3.10	16.60	5.00	5.60	6.00	44.80	5.30	5.30	3.70	3.80
10	4.20	10.00	3.00	10.00	5.50	5.40	10.20	38.00	5.00	5.20	3.70	3.90

Daily gage height, in feet, of Cape Fear River at Fayetteville, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
11	4.50	11.20	3.50	7.00	7.70	5.00	10.00	30.70	4.70	5.20	3.50	3.80
12	4.80	9.30	4.30	6.60	10.50	4.80	8.70	19.80	4.70	5.00	3.50	4.00
13	12.90	10.00	5.30	6.00	10.00	4.40	7.00	11.00	4.40	4.80	3.50	3.90
14	15.40	9.50	5.00	7.00	8.30	6.30	8.00	28.80	4.30	5.00	3.60	4.00
15	11.00	7.40	4.50	20.40	7.00	9.40	30.10	42.00	4.10	9.00	3.60	5.00
16	8.40	6.60	4.00	20.80	5.80	9.00	41.50	40.00	4.00	8.00	3.60	15.40
17	6.70	5.40	3.70	16.00	4.70	14.40	36.50	32.00	7.80	6.20	3.60	16.20
18	9.00	5.00	3.40	11.80	4.40	22.30	29.70	30.00	14.00	5.50	3.50	11.00
19	12.20	5.00	3.20	9.30	5.00	23.00	25.30	26.50	37.50	5.00	3.60	9.20
20	10.00	4.80	3.10	7.50	6.60	15.70	31.10	26.00	43.60	4.50	3.50	7.00
21	8.50	4.50	4.00	8.30	10.00	11.40	33.00	23.80	40.00	4.40	3.50	5.20
22	6.00	4.40	4.50	13.20	14.00	9.00	25.80	20.40	29.00	4.10	3.50	4.60
23	5.20	4.00	4.00	14.00	48.00	13.40	18.20	15.60	21.80	3.80	3.50	4.20
24	4.60	4.00	3.90	12.00	58.50	10.80	12.00	13.40	15.00	4.00	3.70	4.60
25	5.30	4.10	3.80	14.00	54.70	9.00	10.30	20.00	10.40	3.90	6.00	5.60
26	5.30	4.00	5.50	12.00	42.00	8.70	9.00	23.00	8.30	3.80	6.10	7.00
27	5.40	4.00	28.30	9.60	33.90	7.80	6.80	17.80	7.20	4.00	5.00	7.30
28	5.20	3.90	36.00	8.00	27.50	9.20	5.60	15.60	7.30	3.80	4.70	12.00
29	4.60	.....	32.00	7.00	27.20	16.60	5.40	16.40	9.00	3.60	4.50	16.00
30	4.60	.....	25.80	6.10	23.00	11.20	5.00	16.00	10.00	3.60	3.80	25.20
31	5.00	.....	19.70	.....	18.00	.....	4.60	12.50	.....	3.50	.....	35.50
1902.												
1	35.50	17.00	40.50	16.80	7.00	3.10	4.40	2.70	1.00	3.90	2.60	7.60
2	30.00	27.70	41.70	12.60	7.00	2.90	3.30	2.30	.90	4.40	2.30	20.00
3	22.00	39.80	39.80	10.20	5.80	2.80	2.70	2.30	.90	5.80	2.00	19.20
4	16.60	40.30	33.50	8.00	5.80	2.60	2.40	1.80	.50	4.60	1.90	21.60
5	12.50	35.80	29.30	7.30	5.40	2.50	2.10	1.60	.50	4.00	1.70	19.40
6	9.00	26.20	23.00	10.00	5.00	2.40	1.80	1.40	.80	3.60	1.70	17.80
7	8.00	19.00	19.90	8.80	4.50	2.30	1.60	1.80	.80	5.70	2.30	14.00
8	7.00	14.20	16.80	7.60	4.50	2.10	1.40	2.10	.80	6.00	2.80	11.20
9	6.90	11.00	13.60	8.00	4.50	2.20	1.20	2.10	1.00	5.00	3.20	9.70
10	6.90	9.50	12.90	8.00	4.80	2.40	3.30	1.80	1.10	3.80	3.60	7.00
11	6.80	8.00	12.00	8.50	4.80	2.20	2.80	1.80	4.40	3.30	3.00	6.00
12	6.50	7.90	11.00	11.00	4.50	2.40	2.30	3.00	5.80	3.80	2.50	5.60
13	6.20	7.80	10.20	11.00	4.40	2.50	2.70	3.40	3.80	7.00	2.40	6.00
14	5.80	7.70	9.20	9.60	5.20	2.20	3.50	2.40	3.60	8.00	2.20	16.00
15	5.70	7.50	8.80	8.00	5.00	1.90	2.80	1.60	2.20	6.10	2.10	15.60
16	5.30	6.80	8.70	7.30	6.00	1.90	2.60	1.70	1.50	5.60	1.80	11.20
17	5.30	7.90	11.00	6.80	6.00	2.40	2.30	2.80	1.40	4.70	1.90	9.20
18	5.30	9.00	20.00	6.00	5.40	8.00	2.30	2.80	1.00	3.80	1.90	9.50
19	5.30	9.80	17.80	5.80	6.20	7.80	2.10	2.70	.90	3.00	2.00	10.00
20	5.30	10.00	14.00	11.00	6.50	6.00	1.60	2.40	.90	3.00	6.50	8.40
21	5.20	10.80	11.00	9.60	6.80	5.00	1.30	2.70	.80	2.90	6.60	7.80
22	11.50	12.20	9.80	8.00	5.80	3.70	1.50	2.50	.70	2.50	5.20	7.80
23	19.80	18.50	9.00	7.30	4.40	3.00	1.30	2.20	.80	1.90	4.00	14.80
24	17.20	24.50	8.50	6.80	3.90	2.70	1.00	2.20	.70	2.00	3.50	14.00
25	12.80	26.90	8.30	6.00	3.60	2.70	1.00	2.20	.50	2.00	3.00	9.80
26	10.00	35.30	8.00	5.80	3.80	3.40	1.70	2.10	2.00	1.70	3.70	8.60
27	8.00	38.30	7.70	5.70	4.80	4.40	1.60	1.70	4.60	1.60	7.00	7.00
28	7.50	35.00	7.20	5.40	5.00	4.40	1.10	1.40	8.60	1.70	10.00	6.20
29	8.20	.....	7.80	5.10	4.80	4.70	1.50	1.30	8.00	1.90	8.00	5.80
30	10.00	.....	15.60	6.00	4.00	5.30	1.90	1.30	6.20	1.80	5.00	5.30
31	12.20	.....	20.00	.....	3.60	.....	1.80	1.20	.....	2.80	.....	5.80

Rating table for Cape Fear River at Fayetteville, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	450	3.8	1,620	7.2	3,048	14.5	6,650
.6	480	4.0	1,700	7.4	3,136	15.0	6,900
.8	540	4.2	1,780	7.6	3,224	15.5	7,150
1.0	600	4.4	1,860	7.8	3,312	16.0	7,450
1.2	660	4.6	1,940	8.0	3,400	16.5	7,725
1.4	720	4.8	2,020	8.5	3.650	17.0	8,000
1.6	780	5.0	2,100	9.0	3,900	17.5	8,275
1.8	840	5.2	2,180	9.5	4,150	18.0	8,550
2.0	900	5.4	2,260	10.0	4,400	19.0	9,200
2.2	980	5.6	2,344	10.5	4,650	20.0	9,850
2.4	1,060	5.8	2,432	11.0	4.900	25.0	13,350
2.6	1,140	6.0	2,520	11.5	5,150	30.0	18,600
2.8	1,220	6.2	2,608	12.0	5,400	35.0	26,350
3.0	1,300	6.4	2,696	12.5	5,650	40.0	35,050
3.2	1,380	6.6	2,784	13.0	5,900	45.0	43,800
3.4	1,460	6.8	2,872	13.5	6,150	50.0	53,550
3.6	1,540	7.0	2,960	14.0	6,400		

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.

[Drainage area, 4,493 square miles.]

NOTE.—For the years 1889 to 1900, inclusive, the discharge curve above 30 feet gage-height is not well determined. The discharges above 30 feet gage-height are, therefore, approximate for those years. The first discharge measurement was made in 1895. The computed discharges for 1889 to 1892, inclusive, are from measurements made during the years 1895 to 1899. The bed of the stream is believed to have changed but little from 1889 to 1899.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1889.						
January	41,250	3,570	17,373	3.87	4.46	6.11
February	53,250	4,500	17,244	3.84	4.00	3.94
March	14,660	2,000	5,441	1.21	1.39	2.99
April	13,610	1,910	5,395	1.20	1.34	3.69
May	6,580	1,042	1,978	.44	.51	4.85
June	46,050	1,910	7,082	1.58	1.76	4.27
July	58,150	2,805	20,784	4.63	5.33	10.38
August	56,150	2,385	15,881	3.53	4.07	6.60
September	8,180	2,135	3,452	.77	.85	3.20
October	18,910	1,108	3,348	.75	.86	3.36

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1889.						
November	29,350	2,695	7,834	1.74	1.94	4.31
December	8,180	1,515	2,451	.54	.63	.59
The year	58,150	1,108	9,022	2.01	27.14	54.29
1890.						
January	3,245	1,515	1,921	0.43	0.49	1.93
February	13,610	1,730	5,073	1.13	1.16	3.77
March	16,970	3,050	7,381	1.64	1.89	2.71
April	8,580	2,485	3,948	.88	.98	2.20
May	8,660	1,275	3,666	.82	.94	4.93
June	5,780	1,075	2,435	.54	.62	3.51
July	13,610	550	2,763	.62	.71	6.08
August	18,360	1,820	7,898	1.77	2.04	3.18
September	26,190	1,475	5,397	1.20	1.34	5.34
October	16,550	1,275	3,775	.84	.97	5.31
November	4,350	1,555	3,125	.70	.78	.22
December	13,820	1,730	4,368	.97	1.12	4.15
The year	26,190	550	4,312	.96	13.04	43.33
1891.						
January	14,870	2,920	6,994	1.56	1.79	5.13
February	44,030	3,570	10,419	2.32	2.41	5.12
March	48,450	5,140	14,955	3.33	3.84	7.89
April	13,610	2,585	6,595	1.47	1.64	2.50
May	58,400	1,775	9,274	2.06	2.38	7.86
June	28,270	1,515	5,839	1.29	1.43	3.43
July	9,060	1,775	3,925	.87	1.00	7.31
August	53,490	1,955	15,851	3.53	4.07	9.13
September	20,236	1,730	4,864	1.08	1.21	1.36
October	4,350	1,315	2,301	.51	.59	1.93
November	5,140	1,174	1,660	.37	.41	2.98
December	7,460	2,695	3,501	.78	.90	1.84
The year	58,400	1,174	7,181	1.60	21.67	56.48
1892.						
January	69,700	2,920	14,162	3.15	3.63	6.28
February	18,470	2,920	4,676	1.04	1.12	3.20
March	20,362	2,805	5,881	1.31	1.51	2.93

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1892.						
April	34,090	3,440	8,090	1.80	2.01	2.56
May	8,500	2,885	3,437	.76	.88	4.05
June	13,610	1,865	5,506	1.23	1.37	5.90
July	11,010	1,475	5,336	1.19	1.37	5.75
August	2,285	440	1,410	.31	.36	2.95
September	3,180	464	1,294	.29	.32	2.33
October	976	440	604	.13	.15	.46
November	3,245	440	1,413	.31	.35	3.60
December	8,500	700	2,054	.46	.53	2.95
The year	69,700	440	4,488	1.00	13.60	42.96
1893.						
January	16,461	1,145	3,865	0.86	0.99	2.81
February	41,873	3,010	18,596	4.14	4.31	6.11
March	12,453	2,264	4,356	.97	1.12	1.48
April	3,334	1,517	2,211	.49	.55	2.03
May	27,137	1,145	3,046	.68	.78	5.31
June	16,627	1,367	3,619	.80	.89	5.38
July	2,470	519	1,063	.24	.28	3.13
August	19,587	550	2,798	.62	.71	7.52
September	37,390	1,417	9,341	2.08	2.32	5.81
October	41,467	1,417	8,454	1.88	2.17	6.56
November	6,613	1,890	2,692	.60	.67	1.70
December	19,723	2,578	5,750	1.28	1.48	2.93
The year	41,873	519	5,483	1.22	16.27	50.77
1894.						
January	21,082	2,740	6,911	1.54	1.78	4.03
February	22,441	3,766	7,820	1.74	1.81	3.67
March	22,712	2,686	5,973	1.33	1.53	1.51
April	4,102	1,367	2,207	.49	.55	1.61
May	5,245	1,229	2,418	.54	.62	4.48
June	3,384	489	1,006	.22	.25	2.33
July	7,393	678	1,911	.43	.48	6.34
August	31,137	1,417	7,193	1.60	1.84	5.50
September	9,099	612	2,330	.55	.61	5.69

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1894.						
October	49,485	2,318	9,770	1.95	2.25	6.76
November	11,569	1,940	3,779	.83	.92	1.75
December	9,967	1,674	3,386	.75	.86	2.85
The year	49,485	489	4,559	1.00	13.40	46.53
1895.						
January	90,650	2,632	18,334	4.08	4.70	7.36
February	22,441	4,214	9,299	2.07	2.15	2.38
March	40,108	4,550	13,867	3.09	3.56	5.71
April	49,213	3,990	15,646	3.48	3.89	9.21
May	44,728	3,280	5,500	1.22	1.41	3.64
June	6,193	1,620	2,912	.65	.72	4.08
July	12,928	1,728	3,833	.85	.98	5.66
August	11,840	1,187	3,439	.76	.87	5.29
September	2,156	581	1,232	.27	.30	.62
October	810	399	608	.14	.16	1.70
November	4,270	1,075	1,833	.41	.46	3.26
December	10,029	1,008	2,737	.61	.70	3.88
The year	90,650	399	6,603	1.48	19.90	52.79
1896.						
January	19,723	1,620	6,273	1.40	1.61	2.78
February	49,621	2,956	14,436	3.21	3.46	6.63
March	5,477	2,318	3,498	.78	.90	2.27
April	14,287	1,367	3,216	.72	.80	1.62
May	6,553	843	2,774	.62	.71	4.88
June	11,569	1,041	3,593	.80	.89	6.94
July	52,340	1,319	10,827	2.41	2.78	7.11
August	1,782	612	1,116	.25	.29	1.67
September	4,616	430	1,435	.32	.36	7.59
October	26,458	843	3,210	.71	.82	1.42
November	10,339	975	2,435	.54	.60	4.03
December	8,113	1,940	4,058	.90	1.04	2.14
The year	52,340	430	4,739	1.06	14.26	49.08

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1897.						
January	17,688	1,580	3,694	0.82	0.94	2.29
February	33,688	2,255	12,802	2.85	2.97	5.23
March	35,708	3,100	12,233	2.72	3.14	4.79
April	22,788	1,760	6,871	1.53	1.71	3.46
May	9,760	1,580	3,191	.71	.82	4.58
June	3,860	750	1,833	.41	.46	3.34
July	18,708	780	3,180	.71	.82	6.63
August	2,900	875	1,570	.35	.40	3.74
September	1,850	360	664	.15	.17	1.68
October	875	340	517	.12	.14	2.25
November	4,520	630	1,281	.29	.32	3.82
December	4,700	1,180	2,165	.48	.55	2.56
The year	35,708	340	4,166	.93	12.44	44.37
1898.						
January	7,333	1,319	2,126	0.47	0.54	2.00
February	2,740	1,145	1,735	.39	.41	.92
March	12,249	1,273	3,303	.74	.85	4.38
April	13,608	1,620	4,395	.98	1.09	3.38
May	6,133	1,145	2,369	.53	.61	3.68
June	3,280	519	1,181	.26	.29	2.92
July	8,665	489	2,793	.62	.71	5.68
August	24,072	910	5,655	1.26	1.45	7.80
September	10,277	876	3,674	.82	.91	3.79
October	4,955	612	1,739	.39	.45	4.30
November	7,333	1,417	2,982	.66	.73	3.16
December	9,781	1,994	3,387	.75	.86	2.17
The year	24,072	489	2,945	.66	8.90	44.18
1899.						
January	16,462	1,940	5,116	1.14	1.31	4.02
February	69,200	4,955	25,842	5.75	5.98	8.31
March	48,200	4,214	17,042	3.79	4.31	6.85
April	34,600	3,064	8,408	1.87	2.09	3.17
May	9,347	1,782	3,706	.82	.85	4.01
June	5,593	984	2,280	.51	.57	3.37
July	6,613	910	2,481	.55	.63	6.79

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1899.						
August	5,833	645	1,947	0.43	0.44	2.14
September	2,578	612	1,133	.25	.28	3.58
October	9,161	612	2,132	.47	.54	4.65
November	13,482	1,319	3,151	.70	.78	1.89
December	7,333	1,674	2,992	.67	.77	3.24
The year	69,200	612	6,352	1.41	18.65	52.02
1900.						
January	13,336	1,620	4,001	0.89	1.03	2.47
February	35,600	1,890	10,058	2.24	2.33	5.20
March	31,060	3,280	8,649	1.92	2.21	4.53
April	52,400	2,524	11,848	2.64	2.94	4.68
May	9,781	1,467	2,969	.66	.76	3.04
June	9,409	984	2,688	.60	.67	5.50
July	6,133	459	1,472	.33	.38	3.49
August	1,940	350	736	.16	.18	3.00
September	5,187	310	1,010	.22	.25	2.74
October	1,145	375	526	.12	.14	2.18
November	6,433	350	1,258	.28	.31	3.77
December	8,541	843	2,816	.63	.73	4.20
The year	52,400	310	4,003	.89	11.93	44.80
1901.						
January	7,120	1,600	3,048	0.68	0.78	2.47
February	4,850	1,560	2,659	.59	.61	1.68
March	28,050	1,200	4,209	.94	1.08	3.88
April	49,065	2,440	9,624	2.14	2.39	5.34
May	71,625	1,560	11,502	2.56	2.95	8.75
June	11,800	1,760	4,352	.97	1.08	5.68
July	37,675	1,520	8,072	1.80	2.08	8.11
August	43,450	1,440	13,965	3.11	3.59	11.85
September	41,350	1,600	7,296	1.62	1.81	5.47
October	4,450	1,400	2,342	.52	.60	1.13
November	2,440	1,400	1,555	.35	.39	1.34
December	27,200	1,440	3,828	.85	.98	5.18
The year	71,625	1,200	6,038	1.34	18.34	60.88

Estimated monthly discharge of Cape Fear River at Fayetteville, N. C.—Continued.

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	Inches.
1902.						
January	27,200	2,180	5,353	1.19	1.37	2.35
February	35,575	2,872	11,746	2.61	2.72	5.73
March	37,825	3,048	9,612	2.14	2.47	3.16
April	7,890	2,140	3,695	.82	.91	3.18
May	2,960	1,540	2,159	.48	.55	2.63
June	3,400	870	1,466	.33	.37	3.46
July	1,860	600	965	.21	.24	2.88
August	1,460	660	961	.21	.24	3.59
September	3,700	450	1,074	.24	.27	5.24
October	3,400	780	1,633	.36	.42	3.26
November	4,400	810	1,540	.34	.38	3.64
December	10,890	2,220	4,956	1.10	1.27	3.67
The year	37,825	450	3,763	.84	11.21	42.79

ROCKFISH CREEK NEAR BRUNT, N. C.

This station was established on October 29, 1902, by B. S. Drane. The course of the creek is straight here for about 500 yards, Lower Rockfish Bridge crossing the creek near the middle of this straight stretch. The left side of the stream is shallow, most of the current flowing along the right bank. The banks of the creek, of sand, rise steeply on either side to a height of about 50 feet.

The gage rod is of pine, 12 feet long, well painted, and divided into tenths and half-tenths of a foot. It is firmly nailed on the outside of the downstream hand rail, between the two large posts, approximately over the center of the bridge. The distance from the zero of the gage to the outer rim of the pulley is 1 foot. The length of the wire, from the end of the weight to the pointer, is 51.80 feet. The gage reads zero when the weight touches the bottom.

The observer is C. L. Nunalee, a farmer and storekeeper; his post-office address is Brunt, N. C.

The station is reached by driving from Fayetteville, N. C., a distance of 7 miles.

The following discharge measurements were made during 1902 by B. S. Drane.

September 6: Rockfish Creek discharge, 318 second-feet.
September 6: Big Rockfish Creek discharge, 126 second-feet.
September 6: Little Rockfish Creek discharge, 161 second-feet.
October 16: Rockfish Creek discharge, 440 second-feet.

Daily gage height, in feet, of Rockfish Creek near Brunt, N. C.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1		3.65	5.26	12		3.57	3.67	23		3.41	6.97
2		3.45	(a)	13		3.71	4.50	24		3.47	7.47
3		3.80		14		3.51	7.77	25		3.57	5.10
4		3.70		15		3.53	7.75	26		3.97	3.75
5		3.80		16		3.52	5.56	27		4.45	3.67
6		2.83	9.67	17		3.40	3.92	28		4.64	3.92
7		4.01	7.87	18		3.57	4.12	29		4.77	3.48
8		4.26	4.90	19		3.90	4.65	30	3.70	3.70	3.78
9		4.03	4.02	20		3.86	3.97	31	3.67		4.20
10		4.20	3.90	21		3.78	4.12				
11		3.72	4.17	22		3.67	4.52				

a Water over gage.

DEEP RIVER AT CUMNOCK, N. C.

This station was established on June 29, 1900, by E. W. Myers. It is 300 yards northwest of the railroad station at Cumnock. The wire gage, which is graduated to feet and tenths, is nailed to the guard rail of the bridge. When the gage reads 3 feet the water surface is 37.41 feet below the top of the lower chord at the side of the tension rod supporting the floor beam opposite the gage. The initial point of sounding is at the northwest end of the bridge. The channel is straight for several hundred feet above and below the bridge, but the current is rather sluggish during low water. The bed of the stream is muddy, with some bowlders. The observer is J. A. Rollins, a watchman at Cumnock. The station was discontinued in June, 1902.

The following discharge measurements were made during 1902 by B. S. Drane:

July 11: Gage height, 1.91 feet; discharge, 224 second-feet.
August 18: Gage height, 1.81 feet; discharge, 228 second-feet.

Daily gage height, in feet, of Deep River at Cumnock, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1902.							1902.						
1	18.54	11.01	14.60	1.54	1.86	2.88	17	1.42	2.94	2.34	2.38	1.92	2.14
2	14.65	18.81	16.97	1.55	1.93	2.86	18	1.40	3.70	2.31	2.33	1.97	2.19
3	11.08	22.02	16.01	1.51	1.98	2.80	19	6.87	3.96	2.26	2.28	2.06	2.24
4	8.90	19.92	14.86	1.48	1.97	2.76	20	5.34	4.06	2.20	2.22	2.19	2.19
5	7.28	17.62	13.55	1.45	1.93	2.60	21	4.32	4.43	2.17	2.19	2.24	2.15
6	5.48	15.05	10.63	1.43	1.92	2.47	22	3.29	6.68	2.08	2.15	2.28	2.10
7	4.33	9.68	6.65	2.57	1.88	2.41	23	2.25	9.42	1.81	2.09	2.32	2.05
8	3.02	6.50	4.72	2.65	1.85	2.33	24	2.44	11.26	1.75	2.02	2.36	2.02
9	2.69	4.26	3.88	2.73	1.82	2.23	25	2.60	11.89	1.71	1.96	2.40	1.97
10	1.91	3.56	3.67	2.84	1.80	2.18	26	2.66	12.47	1.68	1.92	2.42	1.86
11	1.73	2.89	3.38	2.88	1.77	2.17	27	3.38	14.34	1.65	1.86	2.51	1.85
12	1.65	2.56	3.20	2.60	1.76	2.14	28	3.79	15.48	1.64	1.85	2.77	1.90
13	1.57	2.18	3.11	2.54	1.74	2.13	29	3.94	.....	1.62	1.82	2.80	.....
14	1.50	1.96	2.90	2.50	1.71	2.11	30	4.37	.....	1.62	1.81	2.83	.....
15	1.45	2.07	2.63	2.53	1.76	2.08	31	4.77	.....	1.60	.....	2.87	.....
16	1.46	2.42	2.65	2.46	1.86	2.06							

Rating table for Deep River at Cumnock, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	70	4.0	860	7.2	2,950	14.0	8,475
1.0	80	4.2	940	7.4	3,110	14.5	8,888
1.2	100	4.4	1,020	7.6	3,270	15.0	9,300
1.4	126	4.6	1,100	7.8	3,430	15.5	9,712
1.6	160	4.8	1,200	8.0	3,590	16.0	10,125
1.8	203	5.0	1,300	8.5	3,990	16.5	10,538
2.0	250	5.2	1,420	9.0	4,390	17.0	10,950
2.2	298	5.4	1,540	9.5	4,790	17.5	11,375
2.4	346	5.6	1,680	10.0	5,190	18.0	11,800
2.6	394	5.8	1,830	10.5	5,595	19.0	12,650
2.8	442	6.0	1,990	11.0	6,000	20.0	13,500
3.0	490	6.2	2,150	11.5	6,413	25.0	17,750
3.2	550	6.4	2,310	12.0	6,825	30.0	22,000
3.4	620	6.6	2,470	12.5	7,237	35.0	26,250
3.6	700	6.8	2,630	13.0	7,650		
3.8	780	7.0	2,790	13.5	8,063		

Estimated monthly discharge of Deep River at Cumnock, N. C.

[Drainage area, 1,110 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	12,268	126	1,653	1.49	1.72
February	15,200	238	4,597	4.14	4.31
March	10,908	160	2,058	1.85	2.13
April	466	134	286	.26	.29
May	454	181	276	.25	.29
June 1 to 28	466	214	[a] 309	[a] .28	[a] .29

[a] Partial month; station discontinued.

MISCELLANEOUS MEASUREMENTS IN CAPE FEAR RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in the Cape Fear River drainage basin during 1902:

Date.	Place.	Gage height.	Discharge.
		Feet.	*Second-feet.*
Oct. 1	Lower Little River, near Manchester, N. C.	19.57	491
Oct. 2	do	19.85	410

PRECIPITATION OVER THE DRAINAGE BASIN OF CAPE FEAR RIVER.

The precipitation over the area drained by Cape Fear River is comparatively large. For the period covered by the records given herewith it is 50.34 inches per annum, on an average, distributed approximately through the seasons as follows: Spring, 12.5 inches; summer, 16.1 inches; autumn, 10.2 inches; winter, 11.5 inches. This distribution is not very conducive to a large run-off, since the greatest precipitation occurs in the spring and summer, when the amounts lost by evaporation and by the demands of plant life are greatest; nor is it conducive to great regularity of flow.

While the table showing the average annual precipitation over the basin indicates that there may be a considerable range in this quantity, the actual variations are in all probability greater than are there indicated, since the table unavoidably covers only a period when most of the years were of less than normal rainfall. In several of these years there were periods of drought more severe than had ever been

experienced before on the basin, as is evidenced by the fact that many wells which had never before been known to fail became totally dry during these times.

The records at the Fayetteville station are probably more complete in certain respects than those at any other station in the basin. At this place the total range in precipitation has been between 102 and 37 inches. An approximately equal range will probably be found to obtain at all the other stations in the basin, when the records have been continued long enough to obtain the extremes; though it is very improbable that the range of precipitation over the basin as a whole will ever reach this amount.

The following table gives a list and the location of the rainfall stations in the drainage basin of Cape Fear River, and these are also indicated on the accompanying map of the area (see fig. 3).

Location of rainfall stations in basin of Cape Fear River.

Station.	County.	State.	Latitude.		Longitude.		Elevation.
			°	′	°	′	*Feet.*
Fayetteville	Cumberland	North Carolina	35	6	78	53	170
Southern Pines	Moore	do	35	13	79	22	400
Moncure	Chatham	do	35	39	79	00	300
Pittsboro	do	do	35	42	79	12	480
Chapel Hill	Orange	do	35	54	79	4	500
Soapstone Mountain	Randolph	do	35	46	79	37	900
Greensboro	Guilford	do	36	4	79	49	843
Oak Ridge	do	do	36	10	80	00	885

The eight following tables give for each precipitation station for the years 1889 to 1902, so far as covered by the observations, the monthly precipitation, the yearly total, and the mean monthly and yearly precipitation.

The next table, on page 56, gives for the entire drainage area the monthly and yearly precipitation for each year from 1889 to 1902, inclusive, and the mean monthly and yearly precipitation for the entire period. This table is based upon the eight preceding tables.

The next table, on page 57, gives a comparison for the years 1889 to 1902, inclusive, between the mean yearly run-off from the drainage area as determined by the observations at Cape Fear River station at Fayetteville, and the mean yearly precipitation as determined from the eight stations in the preceding tables.

The quantities in all the tables are given in inches.

The next table, on page 58, shows the relation of run-off, rainfall, and temperature.

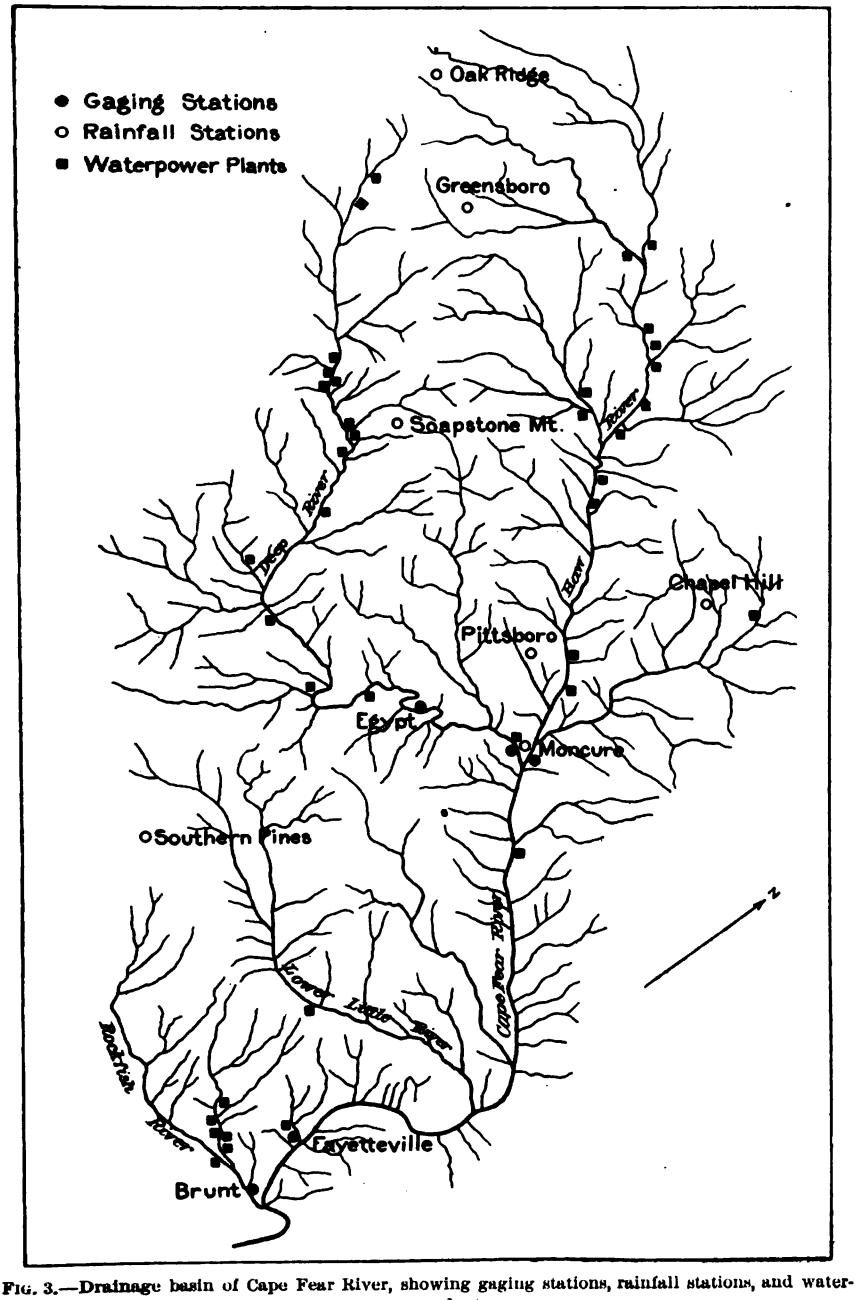

FIG. 3.—Drainage basin of Cape Fear River, showing gaging stations, rainfall stations, and water-power plants.

Precipitation, in inches, at Fayetteville, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1891	4.50	3.80	7.84	2.74	4.56	3.15	6.05	9.57	1.84	4.51	2.52	2.04	53.12
1892	7.57	2.99	3.04	1.99	4.79	3.75	10.32	4.64	2.44	.34	2.12	3.57	47.56
1893	3.15	4.60	2.08	1.63	7.67	5.77	3.39	7.36	5.10	4.73	2.39	3.44	51.31
1894	4.58	3.47	2.10	1.30	5.31	2.12	4.26	13.45	6.68	9.16	1.51	1.84	55.78
1895	7.67	2.41	6.07	9.21	4.12	1.89	5.61	6.56	2.47	2.50	2.21	2.30	53.02
1896	3.98	5.52	2.13	1.15	8.06	7.15	5.52	1.74	9.01	1.36	2.51	3.45	51.58
1897	1.31	3.63	4.05	2.77	5.88	2.94	11.11	5.41	1.42	2.17	3.43	2.13	46.25
1898	2.19	1.02	2.93	4.75	1.59	5.53	5.97	7.46	2.43	2.70	4.95	2.86	44.38
1899	3.60	10.10	5.32	3.40	2.35	4.03	8.35	3.76	5.29	3.81	1.90	2.76	54.67
1900	1.86	3.75	3.52	3.51	2.53	6.47	2.56	1.26	2.77	1.26	3.52	4.89	37.90
1901	2.62	1.91	3.78	3.46	7.98	4.31	7.81	7.80	5.47	1.21	.73	5.34	52.42
1902	2.20	6.18	2.44	2.75	1.84	2.37	2.50	2.80	5.24	2.00	3.28	3.78	37.38
Normals	5.21	4.31	5.30	4.36	4.71	4.18	8.09	6.77	5.20	4.45	3.30	5.25	61.13

NOTE.—Observations have been made here for a much longer period than is given above. The normals, as given, are from the entire series of records.

Precipitation, in inches, at Southern Pines, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1889	5.50	3.65	3.65	5.56	5.00	3.90	9.00	8.50	2.50	4.00	4.20	1.00	56.46
1890	No record.												
1891	3.70	5.70	7.18	1.26	11.08	3.70	7.32	10.58	.68	2.11	2.86	1.26	57.43
1892	7.01	3.20	3.35	3.62	5.27	4.96	10.83	5.05	1.78	.34	2.80	4.05	52.26
1893	2.75	7.10	1.70	2.10	3.90	7.10	7.06	5.12	3.71	5.81	1.40	5.84	53.59
1894	3.33	2.74	1.44	1.90	2.94	2.85	10.48	7.13	5.75	6.97	1.07	2.40	49.00
1895	7.60	2.39	8.78	6.83	2.07	4.79	4.93	5.99	.11	1.87	.55	3.54	49.45
1896	3.02	[4.62]	.90	.50	3.40	[4.65]	7.90	[6.44]	5.00	2.10	4.89	2.98	46.40
1897	1.39	6.79	4.50	4.07	2.52	4.83	7.96	4.01	.83	1.87	3.25	1.68	43.70
1898	1.89	1.37	3.77	4.39	3.12	3.52	8.46	7.44	2.88	5.62	4.15	1.82	48.43
1899	3.79	9.33	6.93	3.97	3.02	6.02	10.65	1.76	4.84	7.78	2.86	2.28	64.13
1900	1.63	5.94	4.38	4.77	3.33	5.02	2.56	3.88	1.97	1.02	4.38	5.78	44.66
1901	3.17	1.81	5.35	5.73	8.88	5.59	13.23	13.43	9.59	.46	1.93	4.86	74.03
1902	3.31	5.41	2.70	3.00	2.28	2.66	4.19	4.35	5.73	2.87	4.20	3.03	43.73
Normals	3.70	4.62	4.20	3.67	4.37	4.65	8.03	6.44	3.49	3.29	2.96	3.12	52.56

Precipitation, in inches, at Moncure, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1894	[2.87]	[4.27]	[4.04]	1.24	5.32	1.30	6.47	5.00	3.95	6.13	1.99	2.69	45.27
1895	8.61	2.56	5.53	10.74	2.95	4.22	5.93	6.47	.41	1.93	3.25	2.78	55.38
1896	1.53	6.37	2.30	1.61	3.72	5.13	6.77	2.63	6.78	1.60	4.04	1.68	44.16
1897	1.46	4.32	4.23	2.89	3.15	3.59	3.23	2.74	2.39	1.81	3.68	2.28	35.77
1898	1.75	1.00	4.98	2.90	3.81	1.35	3.81	6.94	4.09	2.68	2.53	1.33	37.17
1899	2.90	7.59	5.45	2.46	4.68	2.29	8.76	2.56	5.41	4.98	1.13	2.23	50.44
1900	1.75	3.85	3.94	4.43	2.42	6.74	2.27	3.64	2.21	1.35	3.35	3.95	39.90
1901	2.30	1.49	3.47	5.30	9.53	4.80	7.71	11.65	5.78	1.01	1.70	4.28	59.02
1902	2.65	6.98	2.45	3.80	2.37	3.11	2.97	2.26	4.83	2.45	2.79	4.84	41.50
Normals	2.87	4.27	4.04	3.93	4.22	3.62	5.32	4.88	3.98	2.66	2.72	2.90	45.40

Precipitation, in inches, at Pittsboro, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1889	[3.64]	[4.07]	[3.88]	[3.86]	[4.93]	4.38	8.50	4.70	2.50	3.10	4.30	0.40	48.26
1890	.62	2.50	2.41	1.68	5.55	3.25	5.65	4.20	4.00	4.60	.20	3.55	38.21
1891	4.30	3.80	7.00	1.70	7.00	3.60	7.10	8.80	.80	1.50	2.55	1.00	49.15
1892	5.55	2.90	2.40	2.70	4.20	4.55	4.30	.92	.40	.01	2.40	3.00	33.33
1893	3.75	6.16	1.05	2.45	3.15	3.35	2.03	5.10	6.06	5.70	1.32	3.40	43.52
1894	4.95	3.50	1.19	1.43	5.42	2.11	7.10	5.72	6.43	7.19	1.63	3.54	50.21
1895	9.21	1.85	4.80	13.40	2.61	7.00	5.60	5.36	.70	2.35	6.57	4.10	63.55
1896	3.80	6.82	2.90	1.42	5.50	7.11	8.80	2.66	6.15	1.28	4.73	1.94	53.11
1897	4.53	5.61	5.82	3.70	5.09	4.51	6.62	3.05	3.25	2.40	3.28	2.54	50.40
1898	1.77	.62	5.03	3.07	3.30	2.72	6.25	9.25	4.19	3.57	2.54	1.75	44.06
1899	3.42	7.38	6.27	3.55	4.91	2.19	7.79	4.55	3.71	6.39	1.49	1.86	53.51
1900	2.38	5.99	4.56	5.75	3.79	5.98	2.17	4.99	3.67	1.64	4.40	4.30	49.62
1901	1.76	1.90	3.77	4.64	8.66	6.01	7.39	9.55	7.86	1.99	1.37	3.57	58.47
1902	1.28	3.86	3.30	4.63	[4.93]	2.23	3.51	3.11	6.03	2.22	3.46	2.75	41.31
Normals	3.64	4.07	3.88	3.86	4.93	4.21	5.92	5.14	3.98	3.14	2.87	2.69	48.34

Precipitation, in inches, at Chapel Hill, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1889	6.71	4.24	2.33	3.75	6.02	[3.84]	[5.04]	[5.90]	[4.04]	3.35	3.23	0.46	48.91
1890	2.23	3.63	3.80	1.86	4.81	3.66	[5.04]	[5.90]	4.83	5.69	[3.12]	3.35	47.92
1891	4.59	5.70	7.75	2.13	8.75	4.61	5.40	11.71	1.38	1.58	3.12	1.47	58.19
1892	6.22	3.22	2.74	3.15	3.39	6.12	3.72	.82	1.97	.27	4.35	2.77	38.74
1893	3.04	5.41	1.48	1.49	4.04	4.21	2.09	9.13	6.40	6.75	1.54	3.48	49.06
1894	4.30	3.65	1.78	2.04	4.03	1.76	5.80	6.21	7.93	6.84	1.85	2.33	48.52
1895	8.90	2.33	5.12	11.42	3.99	4.60	3.19	4.46	.62	1.13	4.67	3.63	54.06
1896	3.39	6.46	2.54	2.23	6.80	5.06	8.52	1.28	8.39	1.08	3.09	2.23	51.07
1897	2.66	5.66	4.52	3.31	6.98	1.69	6.68	2.74	1.15	3.32	3.77	2.72	45.20
1898	1.85	1.03	5.30	3.11	3.15	2.66	6.38	14.48	4.74	4.39	2.98	2.07	52.14
1899	3.71	7.79	6.79	3.68	4.51	2.26	4.95	1.34	2.47	5.96	2.14	2.24	47.84
1900	3.23	5.08	4.99	6.09	2.62	4.45	6.38	3.61	3.40	1.10	5.00	4.31	50.26
1901	2.39	1.52	3.72	5.89	1.38	5.69	6.12	11.25	4.75	2.13	1.94	4.56	61.34
1902	2.30	6.92	2.95	3.38	2.23	3.10	1.25	3.71	4.51	3.83	2.94	4.88	42.00
Normals	3.97	4.47	3.99	3.82	5.19	3.84	5.04	5.90	4.04	3.39	3.12	2.89	49.66

Precipitation, in inches, at Soapstone Mountain, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1889	[3.51]	[4.72]	[4.61]	[3.53]	[4.55]	3.75	10.00	6.25	4.12	3.00	5.50	0.50	54.04
1890	1.80	4.25	[4.61]	[3.53]	[4.55]	3.62	6.50	[5.21]	6.25	6.25	.25	6.75	53.57
1891	9.62	5.80	10.50	2.70	7.50	3.25	8.00	6.88	2.00	.50	3.50	2.30	62.55
1892	[3.51]	[4.72]	[4.61]	2.24	4.24	6.65	2.37	5.88	3.71	.99	4.51	2.31	45.74
1893	2.33	6.03	1.43	2.20	4.43	5.88	3.46	6.89	6.11	6.89	2.02	2.74	50.41
1894	3.90	4.01	1.76	1.53	2.56	1.71	4.91	2.59	5.09	7.36	2.18	3.22	40.82
1895	6.19	1.81	4.86	7.49	3.08	3.54	5.20	5.54	.28	1.97	2.71	5.49	48.16
1896	2.57	6.30	2.76	1.45	5.10	5.52	10.19	1.44	8.11	1.47	4.39	1.80	51.10
1897	2.93	6.65	4.90	3.61	3.87	3.61	6.88	2.84	1.31	3.14	3.99	3.11	46.84
1898	2.15	2.95	5.42	3.24	2.28	2.51	6.13	8.17	3.83	4.57	3.12	1.81	44.18
1899	3.72	7.51	6.44	3.20	4.78	2.93	3.57	.65	2.67	5.79	1.85	3.38	46.49
1900	2.58	5.89	5.09	5.76	5.71	4.97	1.95	3.32	1.47	3.43	3.71	4.29	48.17
1901	2.22	1.58	4.08	6.04	7.25	5.84	7.57	14.69	4.49	1.05	1.03	6.03	61.87
1902	2.11	5.80	3.42	2.90	3.80	4.34	2.12	2.53	6.61	4.23	5.15	3.70	46.71
Normals	3.51	4.72	4.61	3.53	4.55	4.15	5.63	5.21	4.00	3.62	3.14	3.39	50.05

Precipitation, in inches, at Greensboro, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1892	[2.78]	[4.78]	[4.56]	1.13	3.14	8.46	3.64	0.83	2.28	0.60	4.26	[3.16]	39.62
1893	[2.78]	[4.78]	[4.56]	[3.00]	6.60	4.92	2.46	10.75	6.55	8.78	1.55	[3.16]	59.89
1894	[2.78]	[4.78]	[4.56]	[3.00]	6.32	4.35	5.07	2.48	5.04	5.37	2.87	2.41	49.03
1895	4.38	[4.78]	[4.56]	[3.00]	4.00	2.80	5.46	5.37	.23	.81	3.65	4.37	43.41
1896	2.16	5.53	1.91	2.74	2.85	8.51	9.55	1.18	7.73	1.20	4.11	1.34	48.81
1897	2.15	5.66	5.07	3.38	3.58	2.82	5.35	4.47	2.06	1.51	3.63	3.05	42.73
1898	1.96	.76	4.42	2.68	6.35	2.94	2.71	3.30	2.30	5.34	2.45	2.67	37.88
1899	3.55	8.63	7.94	2.57	4.45	3.65	5.77	1.42	1.76	3.14	2.47	2.34	47.69
1900	3.16	5.97	5.79	3.44	2.30	5.65	6.00	1.69	2.34	3.21	2.72	3.12	45.39
1901	2.72	1.95	2.82	5.66	7.71	7.45	5.70	13.04	3.50	.86	.82	5.72	57.95
1892	2.17	4.95	3.94	2.41	2.51	5.76	2.30	5.61	3.24	5.61	3.08	3.38	44.96
Normals	2.78	4.78	4.56	3.00	4.53	5.21	4.91	4.56	3.37	3.31	2.87	3.16	47.03

Precipitation, in inches, at Oak Ridge, N. C.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1890	1.05	4.70	1.93	3.07	4.44	[4.57]	[6.16]	2.10	6.29	4.68	[2.69]	3.45	45.13
1891	4.09	5.92	7.06	4.46	8.26	2.35	10.99	7.26	1.46	1.35	3.33	2.96	59.49
1892	6.07	3.70	3.10	3.08	3.29	6.84	4.94	2.49	3.71	.78	4.78	1.98	44.76
1893	1.86	7.35	1.07	2.29	7.35	6.42	1.44	8.26	6.75	7.26	1.66	1.60	53.31
1894	3.10	4.67	.78	1.84	3.92	2.45	6.64	1.45	4.68	5.09	.93	3.25	38.80
1895	6.31	3.28	4.83	5.37	6.29	3.83	6.16	3.62	.11	1.05	2.43	4.84	48.12
1896	1.82	9.40	2.75	1.88	3.63	10.08	8.75	.73	9.57	1.26	4.44	1.67	55.98
1897	1.87	5.12	5.21	3.96	5.53	2.71	5.18	4.70	1.05	1.76	3.91	2.93	43.93
1898	2.42	.60	3.20	2.88	4.68	2.15	5.82	5.32	5.08	5.57	2.53	3.09	43.34
1899	7.44	8.17	9.64	2.55	3.39	2.68	4.45	1.12	2.48	2.14	1.32	2.52	47.90
1900	3.17	5.15	4.00	3.66	1.58	4.69	4.02	1.60	4.10	2.26	3.05	2.95	41.23
1901	2.56	1.30	4.02	5.98	8.63	5.72	9.39	13.41	2.29	.34	1.18	7.13	61.95
1902	1.86	5.91	4.59	2.73	3.71	4.89	[6.16]	[4.34]	[3.96]	[2.80]	[2.69]	[3.20]	46.84
Normals	3.36	5.02	4.01	3.37	4.99	4.57	6.16	4.34	3.96	2.80	2.69	3.20	48.52

Precipitation, in inches, over the drainage basin of Cape Fear River.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1889	6.11	3.94	2.99	3.69	4.85	4.27	10.38	6.60	3.20	3.36	4.31	0.59	51.92
1890	1.93	3.77	2.71	2.20	4.93	3.51	6.08	3.18	5.34	5.31	.22	4.15	46.21
1891	5.13	5.12	7.89	2.50	7.86	3.43	7.31	9.13	1.36	1.93	2.98	1.84	56.66
1892	6.28	3.20	2.93	2.56	4.05	5.90	5.75	2.95	2.33	.46	3.60	2.95	43.14
1893	2.81	6.11	1.48	2.03	5.31	5.38	3.13	7.52	5.81	6.56	1.70	2.93	51.58
1894	4.03	3.67	1.51	1.61	4.48	2.33	6.34	5.50	5.69	6.76	1.75	2.85	47.18
1895	7.36	2.38	5.71	9.21	3.64	4.08	5.66	5.29	.62	1.70	3.26	3.88	51.89
1896	2.78	6.63	2.27	1.62	4.88	6.94	7.11	1.67	7.59	1.42	4.03	2.14	50.28
1897	2.29	5.23	4.79	3.46	4.58	3.34	6.63	3.74	1.68	2.25	3.82	2.56	44.35
1898	2.00	.92	4.38	3.37	3.69	2.92	5.68	7.79	3.79	4.31	3.16	2.17	43.95
1899	4.02	8.31	6.85	3.17	4.01	3.37	6.79	2.14	3.58	4.65	1.89	3.24	51.58
1900	2.47	5.20	4.53	4.68	3.04	5.50	3.49	3.00	2.74	2.18	3.77	4.20	44.64
1901	2.47	1.68	3.88	5.34	8.75	5.68	8.11	11.85	5.47	1.13	1.34	5.18	60.88
1902	2.35	5.73	3.16	3.18	2.63	3.46	2.88	3.59	5.24	3.26	3.64	3.67	43.05
Mean	3.72	4.42	3.94	3.47	4.76	4.29	6.10	5.28	3.89	3.23	2.82	3.03	50.34

[a] The precipitation for each month and the mean monthly precipitation were obtained directly from the available observations. The results for annual and mean annual precipitation include values interpolated in incomplete years.

Comparison of yearly rainfall and run-off from the drainage basin of Cape Fear River.

Station.	Normal.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
RAINFALL.								
Fayetteville, N. C.[a]	61.13	.....	.....	53.12	47.56	51.31	55.78	53.02
Moncure, N. C	45.40	.....	.....	.....	.....	.....	45.27	55.38
Pittsboro, N. C	48.34	48.26	38.21	49.15	33.33	43.52	50.21	63.55
Chapel Hill, N. C	49.66	48.91	47.92	58.19	38.74	49.06	48.52	54.06
Southern Pines, N. C	52.56	56.46	.....	57.43	52.26	53.59	49.00	49.45
Soapstone Mountain, N. C	50.05	54.04	53.57	62.55	45.74	50.41	40.82	48.16
Greensboro, N. C	47.03	.....	.....	.....	39.62	59.89	49.03	43.41
Oak Ridge, N. C	48.52	.....	45.13	59.49	44.76	53.31	38.80	48.12
Mean	50.34	51.92	46.21	56.66	43.14	51.58	47.18	51.89
RUN-OFF.								
Cape Fear at Fayetteville	15.74	27.14	13.04	21.67	13.60	16.28	13.40	19.50
Percentage of rainfall	31.3	52.3	28.2	38.2	31.5	31.6	28.4	37.6

Station.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
RAINFALL.							
Fayetteville, N. C.[a]	51.58	46.25	44.38	54.67	37.90	52.42	37.38
Moncure, N. C	44.16	35.77	37.17	50.44	39.90	59.02	41.50
Pittsboro, N. C	53.11	50.40	44.06	53.51	49.62	58.47	41.31
Chapel Hill, N. C	51.07	45.20	52.14	47.84	50.26	61.34	42.00
Southern Pines, N. C	46.40	43.70	48.43	64.13	44.66	74.03	43.73
Soapstone Mountain, N. C	51.10	46.84	44.18	46.49	48.17	61.87	46.71
Greensboro, N. C	48.81	42.73	37.88	47.69	45.39	57.95	44.96
Oak Ridge, N. C	55.98	43.93	43.34	47.90	41.23	61.95	46.84
Mean	50.28	44.35	43.95	51.58	44.64	60.88	43.05
RUN-OFF.							
Cape Fear at Fayetteville	14.26	12.44	8.90	18.65	11.93	18.34	11.21
Percentage of rainfall	28.4	28.0	20.2	36.2	26.7	30.1	26.0

[a] The normal at Fayetteville includes observations previous to 1889. The other normals include the above data only.

Average monthly run-off and average rainfall, showing their difference and the effect of temperature, for the Cape Fear River Basin.

Month.	Average run-off.		Average rain.	Difference.	Average mean temperature.
	Second-feet.	*Inches.*	*Inches.*	*Inches.*	°
January	7,084	1.82	3.72	1.90	39.8
February	10,886	2.53	4.42	1.89	42.7
March	8,314	2.13	3.94	1.81	49.7
April	6,582	1.64	3.47	1.83	59.1
May	4,142	1.05	4.76	3.71	67.9
June	3,271	.81	4.29	3.48	74.9
July	4,958	1.27	6.10	4.83	77.5
August	5,744	1.47	5.28	3.81	75.9
September	3,157	.78	3.89	3.11	74.6
October	2,926	.72	3.23	2.51	58.7
November	2,610	.65	2.82	2.17	49.2
December	3,461	.89	3.03	2.14	42.3
For the average year	5,261	15.74	48.95	2.77	59.4

In order to present the facts regarding the flow of this stream with a greater degree of clearness the following graphical representations of the data given in the foregoing tables have been made.

Fig. 4 shows the relation between the average rainfall over the drainage basin of Cape Fear River and the average discharge of this basin at the gaging station at Fayetteville, N. C., in inches per month over the entire basin. The portion in black represents the average run-offs, the total precipitation being represented by the entire length of each block. The total average run-off is 15.74 inches. The total average precipitation over the basin is 50.34 inches.

This figure may be taken as representing the average condition of affairs on the basin, and it is seen by reference to it that in February, May, July, and August, large amounts of rainfall are to be expected, and that for these months the average run-off of the stream is also large; that for February being the greatest of the year.

Fig. 5 shows the effect on the run-off when the February rains do not occur. This causes a period of low discharge throughout the spring, and though the precipitation in July is greater than the average, and the entire precipitation for the year not abnormally low, the run-off is considerably less than in any other year covered by the records. This figure represents the conditions over the drainage basin in 1898.

The portion in black represents run-off, the precipitation for each month being represented by the entire length of the block for that month. Total run-off, 8.90 inches. Total precipitation, 43.95 inches.

Fig. 6 shows the amount and distribution of rainfall and run-off in inches over the basin of Cape Fear River above Fayetteville, N. C., for 1900. During this year occurred the minimum actual discharge, and the period of minimum discharge for the years 1889 to 1902, inclusive. The total rainfall was 44.64 inches, and the total run-off

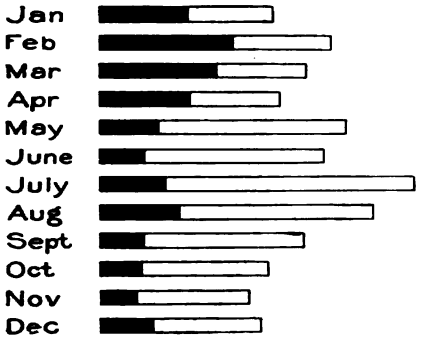

FIG. 4.—Relation of rainfall to run-off, 1889 to 1902, inclusive, in Cape Fear drainage basin.

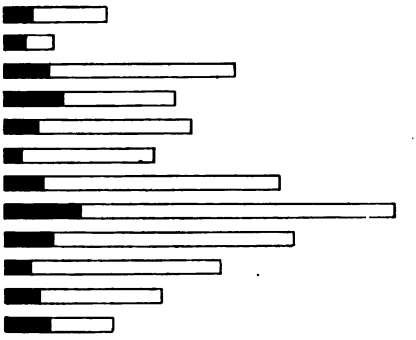

FIG. 5.—Relation of rainfall to run-off for 1898 in Cape Fear drainage basin.

was 11.93 inches. This figure shows also the effect upon the run-off of the absence of the usual rains of May, July, and August, which gave rise to the period of least flow ever recorded.

Fig. 7 shows the relation between that portion of the rainfall not appearing as run-off, and the mean monthly temperatures for the basin of Cape Fear River above Fayetteville, N. C. The portion in

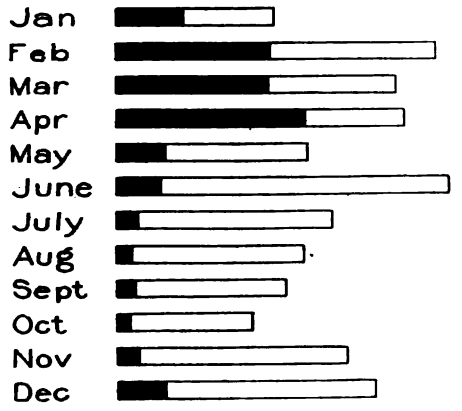

FIG. 6.—Relation of rainfall to run-off for 1900 in Cape Fear drainage basin.

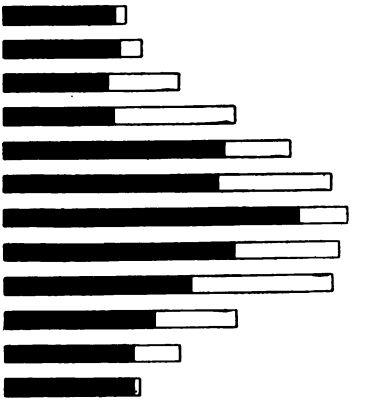

FIG. 7.—Effect of temperature on run-off in Cape Fear drainage basin.

black represents the retained water in inches over the basin; the entire length of block represents to scale the mean monthly temperatures over the basin in degrees. The actual values of these quantities will be found in the table on page 58.

It is evident from the tables and figures preceding, that only a small portion of the rainfall over the drainage basin of the Cape Fear

River appears as run-off in the stream. The remainder of the precipitation has disappeared in various ways. A portion is taken up by the vegetable life of the basin, and a portion disappears through evaporation. In some instances another portion may disappear by subterranean flow. It is, however, improbable that this is the case in the drainage basin of Cape Fear River, and, therefore, the difference between the average run-off and the average precipitation represents the amount taken up by plant life and the loss through evaporation. Both these agencies are to a certain extent dependent upon the temperatures which prevail, and fig. 7 following is the graphical representation of this fact.

The mean monthly temperatures over the basin were calculated from the records kept by the United States Weather Bureau for the period covered by the rainfall and flow observations, so that they are directly comparable.

PEDEE OR YADKIN RIVER DRAINAGE BASIN.

The Yadkin River, or, as it is called below the junction of the Uharie, the Pedee, rises on the eastern slope of the Blue Ridge in Caldwell and Watauga counties, N. C., and flows at first to the southeast, then turns abruptly to the northeast and flows in this direction for about 60 miles, then bends again abruptly and flows toward the south and southeast across North Carolina and South Carolina, emptying into Winyah Bay at Georgetown, S. C. The total length of the stream, from source to mouth, following its general direction, is from 275 to 300 miles, while it is probably 400 miles or more if all the windings be followed.

The Pedee drains a total area of about 17,000 square miles, of which about 9,700 square miles lie in North Carolina and 7,300 in South Carolina. The stream crosses the fall line near Cheraw, S. C., in a series of rapids extending over a number of miles, with no very great fall at any one place or in any short distance.

Small amounts of power may be developed on some of the tributaries of this stream in South Carolina, but the power possibilities of the basin in this State are unimportant. In North Carolina the stream can be made to furnish power in large quantities at a number of places, and large amounts may be secured on many of the tributaries. This stream and its tributaries form one of the most important power regions in the Southern States.

Below the great bend, where the river turns to the south, the valley of the stream averages about 50 miles in width. At many points the river is bordered by wide expanses of bottom lands, which are at times subject to overflow, and which are fertile and very productive. At other places the river is confined between bold and abrupt banks, and in one case it flows for several miles in a very narrow channel, only

60 feet wide in places, in a deep ravine between the flanking hills, forming the noted "Narrows." Above the great bend the valley is only from 15 to 20 miles wide, and the elevations of the divides which separate the basin of the Yadkin from those adjacent are much higher, so that the tributary streams have a large fall.

The upper part of the drainage basin is rough and mountainous and largely forest covered, and throughout this part of its course the flow of the stream is more constant than would be expected.

The average rainfall over the part of the basin in North Carolina is probably between 48 and 51 inches, approximating the lower figure over the lower portions, and possibly exceeding 51 inches over the higher and more mountainous portions, the precipitation increasing as the stream is ascended. This total amount is rather evenly distributed among the seasons. Such a distribution is conducive to considerable variations in flow, and as a consequence the river is subject to freshets; but as a rule these are not so violent as those occurring on many of the other South Atlantic streams, neither rising to such heights nor lasting so long. Freshets on this stream rarely last more than from thirty-six to forty-eight hours. The highest flood ever known at Wilkesboro, it is stated, occurred in March, 1899, the stream at this place rising 28 feet above low water. The greatest flood recorded at the gaging station at Salisbury, N. C., occurred in December, 1901, the stream reaching an extreme height on the gage of 19.7 feet and having a probable discharge of about 130,000 second-feet, or about 38 second-feet per square mile. The flood of March, 1899, produced a rise of about 1 foot less than this flood of December. The most destructive flood ever experienced on the stream occurred in May 1901, but the recorded gage height at the Salisbury station was less for this flood than for either of the others mentioned, and the general testimony of those living along the banks is to the same effect.

The minimum recorded flow at the Salisbury station occurred in September, October, and November, 1897, when the basin of the stream experienced the most severe drouth in its history. The flow fell to 900 second-feet several times during this period; or the basin above the station was discharging at an average rate of 0.26 second-foot per square mile. The maximum flow is thus about 144 times the minimum.

As stated, there are a number of localities where power may be developed.

During 1902, the United States Geological Survey received data for the following stations from E. W. Myers, resident hydrographer: On the Yadkin, near Salisbury, N. C., and at Siloam, N. C.

YADKIN RIVER NEAR SALISBURY, N. C.

The original station was established by C. C. Babb, September 24, 1895, and was located at the Southern Railway bridge near Holtsburg,

near the mouth of Grant Creek, and about 6 miles from Salisbury, N. C. The length of the wire gage was 55.10 feet. The station is easily reached by private conveyance from Salisbury. Discharge measurements were made from the lower side of the deck bridge, the zero point being on the left bank. The channel is obstructed by three piers with large rafts of driftwood lodged against each and sand bars below each. The channel is straight, the current swift, and the bed rough and rocky. The banks are rather low, but all the water passes beneath the bridge during floods.

Owing to the inconvenient location of the railroad bridge from which the measurements were made, and its height above the water, the gaging station was moved June 1, 1899, to the new iron highway bridge about 300 yards above the railroad bridge, the new gage reading the same as the old. In its new position the 10-foot mark on the rod is opposite the center of the first strut from the west end of the second span from the west end of the bridge, on the downstream side. The rod is of pine, 3 inches wide, well painted, graduated to feet and tenths, and securely nailed to the inner surface of the guard rail, the top of the rod being flush with the top of the rail. The distance between the zero of the rod and the outer rim of the pulley is 2.13 feet, and between the end of the weight and the pointer on the wire 26.75 feet. The observer is J. T. Yarbrough, keeper of the bridge. The stream here is of about the same width as at the railroad bridge, and the section is a fairly good one for gaging purposes, the bottom for the greater part of the width of the stream being hard and rocky. At times the current is very materially modified by large quantities of driftwood lodging against the piers, but it is thought better results can be obtained than at the old station. Although this stream is subject to periods of comparatively low flow, the minimum run-off is large.

Discharge measurements of Yadkin River near Salisbury, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
May 12	J. S. Henderson	2.75	4,139
June 13	do	2.56	3,467
July 18	B. S. Drane	2.20	2,788
August 14	do	3.30	7,301
August 29	do	2.07	2,411
September 16	do	2.00	2,119
October 18	do	2.05	2,277
December 3	do	6.52	16,894

Daily gage height, in feet, of Yadkin River near Salisbury, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.60	3.95	9.45	4.20	2.90	2.50	2.85	2.00	1.95	2.05	2.10	5.00
2	2.60	5.75	7.03	3.70	2.80	2.50	2.80	2.80	1.85	2.05	2.15	4.50
3	2.55	6.17	5.35	3.45	2.80	2.50	2.35	2.70	1.80	2.15	2.18	6.00
4	2.95	4.95	4.65	3.35	2.85	2.35	2.30	2.50	2.05	2.10	2.08	5.82
5	3.55	3.90	4.10	3.35	2.80	2.25	2.30	2.05	2.45	2.18	2.25	4.60
6	3.40	3.40	4.05	3.40	2.80	2.15	2.30	2.00	2.20	3.52	2.10	5.30
7	3.30	3.25	3.80	3.25	2.85	2.25	2.40	2.00	1.90	4.55	2.80	3.98
8	3.25	3.20	3.50	3.35	2.85	2.40	2.20	2.10	1.85	2.90	2.55	3.34
9	3.20	3.10	3.50	3.80	2.85	2.70	2.40	2.05	2.10	2.50	2.30	2.95
10	3.15	3.05	3.55	3.45	2.75	2.40	2.40	2.00	4.50	2.30	2.30	2.70
11	3.15	3.00	3.40	3.25	2.55	2.35	3.00	2.10	3.30	2.30	2.08	2.65
12	3.15	2.90	3.30	3.15	2.75	2.88	2.60	2.10	2.50	2.95	2.05	2.60
13	3.00	2.90	3.25	3.20	2.65	2.60	2.40	2.10	2.15	3.50	2.08	2.95
14	2.90	2.85	3.25	3.10	2.70	2.50	2.40	3.42	2.00	2.75	2.08	3.15
15	2.85	2.80	3.20	3.10	2.70	2.65	2.25	4.25	2.00	2.44	2.00	2.85
16	2.95	2.90	3.20	3.10	3.20	6.21	2.05	3.45	2.00	2.25	2.10	2.70
17	2.95	2.90	5.65	3.10	2.90	12.48	2.15	3.15	1.97	2.12	2.15	3.45
18	2.95	2.85	5.00	3.30	2.90	9.57	2.05	2.50	1.85	2.10	3.67	4.52
19	2.90	2.85	3.95	3.35	3.00	4.95	1.95	2.15	1.90	2.25	4.90	3.50
20	2.85	2.85	3.50	3.20	2.90	3.30	2.10	2.00	1.85	2.15	3.80	3.05
21	2.85	2.90	3.30	3.20	2.95	2.90	2.20	2.00	1.85	2.25	2.80	2.88
22	3.90	3.45	3.30	3.10	2.80	2.75	2.40	2.10	2.00	2.05	2.45	3.97
23	3.85	4.20	3.30	3.00	2.80	2.62	2.50	2.55	1.85	1.70	2.40	4.50
24	3.30	3.80	3.20	3.00	2.65	2.50	2.10	2.20	1.80	1.70	2.35	3.60
25	3.15	6.23	3.25	2.95	2.65	2.50	2.00	2.10	1.95	1.90	2.20	3.15
26	3.10	3.37	3.10	2.95	2.85	2.60	2.00	1.90	1.90	2.10	3.00	2.90
27	3.00	6.40	3.05	2.90	2.85	2.60	1.95	1.85	3.85	2.05	3.30	2.75
28	3.35	4.95	3.05	2.95	2.70	3.85	2.20	1.95	3.00	2.95	2.90	2.60
29	3.35	.....	4.00	2.90	2.60	4.30	2.15	1.90	2.40	2.95	2.50	2.60
30	3.40	.....	7.80	2.95	2.50	3.25	2.00	1.88	2.00	2.65	2.50	2.65
31	3.55	.....	5.75	.....	2.45	.....	2.00	1.75	.....	2.20	.....	2.75

Rating table for Yadkin River near Salisbury, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.7	1,350	4.4	10,240	7.2	22,000	13.0	55,700
1.8	1,580	4.6	11,000	7.4	22,900	13.5	59,700
2.0	2,120	4.8	11,800	7.6	23,810	14.0	63,700
2.2	2,720	5.0	12,600	7.8	24,730	14.5	67,900
2.4	3,320	5.2	13,420	8.0	25,650	15.0	72,400
2.6	3,940	5.4	14,240	8.5	28,000	15.5	77,150
2.8	4,580	5.6	15,070	9.0	30,400	16.0	82,000
3.0	5,220	5.8	15,910	9.5	33,000	16.5	87,400
3.2	5,900	6.0	16,750	10.0	35,750	17.0	93,000
3.4	6,580	6.2	17,610	10.5	38,650	17.5	99,000
3.6	7,280	6.4	18,470	11.0	41,700	18.0	105,000
3.8	8,000	6.6	19,340	11.5	44,900	19.0	117,400
4.0	8,720	6.8	20,220	12.0	48,300		
4.2	9,480	7.0	21,100	12.5	51,900		

Estimated monthly discharge of Yadkin River near Salisbury, N. C.

[Drainage area, 3,399 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	8,360	3,780	5,678	1.67	1.93
February	27,295	4,580	8,763	2.58	2.69
March	32,740	5,390	9,759	2.87	3.31
April	9,480	4,900	6,031	1.77	1.97
May	5,900	3,470	4,530	1.33	1.53
June	55,700	2,570	7,700	2.27	2.53
July	5,220	1,980	2,974	0.88	1.01
August	9,670	1,465	3,108	0.91	1.05
September	10,620	1,580	2,871	0.84	0.94
October	10,810	1,350	3,512	1.03	1.19
November	12,200	2,120	3,833	1.13	1.26
December	16,750	3,940	7,273	2.14	2.47
The year	55,700	1,350	5,502	1.62	21.88

YADKIN RIVER AT SILOAM, N. C.

This station was established on August 2, 1900, by N. C. Curtis and Cleveland Abbe, jr., as an aid to the study of the hydrographic conditions of the area which it was proposed to incorporate within the limits of the projected Appalachian Forest Reserve.

This station was located at a ferry across the river at Siloam, a small station on the Wilkesboro branch of the Southern Railway, the measurements being made from the ferryboat. The gage rod was securely braced and nailed to an overhanging tree about 50 yards above the ferry, and was referred to a bench mark on the south bank. This bench mark consisted of a notch cut in the outermost of a group of three sycamore trees standing at the water's edge, about 25 feet above the ferry landing, the notch being about 8 feet from the ground.

When the gage was established the reading was 2.7 feet, and the water level stood 9.6 feet below the bench mark. This gage was insecurely fastened and was washed away by a freshet on September 16, and was not replaced until October 1. The zero of the second gage was made to read 0.5 foot lower than the first. This second gage rod was destroyed by flood on April 19, 1901, and was replaced April 29, 1901. The two former gages had failed by the breaking off of the lower end by logs and drift. The lower end of the new gage was

therefore braced and wedged among the rocks of the bed of the river, and was also braced by means of guy wires to the adjacent trees. The zero of this gage was for this reason made to read 1 foot below the reading of the original gage.

The gage heights printed herewith have been adjusted to the gage as originally established.

The rise of the stream in ordinary freshets is not more than 9 feet, but in 1898, as shown by flood marks and according to verbal accounts, the rise was about 16 feet on the gage, and in 1901 on two occasions the extreme rise was more than 20 feet, the flood waters extending across the bottom land for one-third of a mile or more and touching the railway tracks at Siloam.

The initial point for soundings was on the right bank at the outer edge of a mooring stake at the ferry landing. The section at ordinary stages of the stream is good, the bed being of compact sand and gravel, shifting slightly, if at all, and the banks are high and are rarely submerged. Gagings can not be made in time of flood because of the impossibility of handling a boat in the swift current.

The station was abandoned on December 31, 1901.

Discharge measurements of Yadkin River at Siloam, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 11	N. C. Curtis	2.90	1,367
August 3	do	2.60	1,218
October 31	do	3.10	1,469
1901.			
April 15	N. C. Curtis	5.00	5,237

Daily gage height, in feet, of Yadkin River at Siloam, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
1									2.00	2.60	3.00	3.10
2									2.00	2.60	3.00	3.10
3								2.10	2.00	2.70	3.30	3.20
4								2.05	2.00	2.70	3.10	3.20
5								2.00	2.00	2.80	2.90	3.10
6								1.95	2.00	2.80	2.90	3.10
7								1.90	2.00	2.80	2.90	3.10
8								1.90	2.00	2.90	3.00	3.10
9								1.90	2.00	2.80	3.00	3.10
10								1.80	2.00	2.80	2.90	3.20
11								1.80	2.00	2.80	2.90	3.20
12								1.80	2.00	2.80	2.90	3.20

Daily gage height, in feet, of Yadkin River at Siloam, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
13	.....	.....	.....	.....	.....	.....	.....	1.85	2.00	3.10	2.90	3.10
14	.....	.....	.....	.....	.....	.....	.....	2.05	2.05	2.90	2.90	3.10
15	.....	.....	.....	.....	.....	.....	.....	2.10	2.20	2.80	2.90	3.10
16	.....	.....	.....	.....	.....	.....	.....	2.10	.....	2.80	3.00	3.10
17	.....	.....	.....	.....	.....	.....	.....	2.10	.....	2.80	3.00	3.10
18	.....	.....	.....	.....	.....	.....	.....	2.10	.....	2.80	3.00	3.10
19	.....	.....	.....	.....	.....	.....	.....	2.10	.....	2.80	3.00	3.10
20	.....	.....	.....	.....	.....	.....	.....	2.10	.....	2.80	3.00	3.10
21	.....	.....	.....	.....	.....	.....	.....	2.60	.....	2.80	3.10	3.20
22	.....	.....	.....	.....	.....	.....	.....	3.05	.....	3.10	3.10	3.20
23	.....	.....	.....	.....	.....	.....	.....	2.95	.....	3.60	3.00	3.20
24	.....	.....	.....	.....	.....	.....	.....	3.00	.....	11.70	3.00	3.20
25	.....	.....	.....	.....	.....	.....	.....	2.90	.....	5.00	3.30	3.10
26	.....	.....	.....	.....	.....	.....	.....	2.75	.....	4.10	11.80	3.10
27	.....	.....	.....	.....	.....	.....	.....	2.70	.....	3.90	11.30	3.20
28	.....	.....	.....	.....	.....	.....	.....	2.00	.....	3.70	11.10	3.20
29	.....	.....	.....	.....	.....	.....	.....	2.00	.....	3.10	9.50	3.20
30	.....	.....	.....	.....	.....	.....	.....	2.00	.....	3.10	3.30	3.60
31	.....	.....	.....	.....	.....	.....	.....	2.00	.....	3.10	.....	3.70
1901.												
1	3.20	3.30	3.10	3.30	4.50	4.60	8.60	4.60	4.70	4.60	4.60	4.60
2	3.20	3.30	3.10	3.30	4.50	4.50	8.60	4.70	4.60	4.60	4.60	4.60
3	3.30	3.30	3.10	3.20	4.60	4.50	4.70	4.70	4.60	4.60	4.60	4.60
4	3.20	3.30	3.10	3.20	4.60	4.50	4.70	4.60	4.60	4.60	4.60	4.90
5	3.20	3.30	3.30	3.30	4.50	4.60	5.10	4.60	4.70	4.60	4.60	4.80
6	3.30	3.30	3.20	3.30	4.50	4.60	5.80	4.60	4.70	4.60	4.60	4.60
7	3.30	3.40	3.20	3.30	4.50	4.50	4.60	4.70	4.60	4.70	4.60	4.60
8	3.20	3.30	3.20	3.30	4.60	4.50	4.70	4.70	4.60	4.70	4.60	4.60
9	3.20	3.40	3.40	3.20	4.50	4.60	4.70	4.60	4.60	4.60	4.60	4.60
10	3.40	3.40	3.60	3.20	4.50	4.60	4.70	4.60	4.60	4.60	4.60	4.60
11	3.70	3.30	3.50	3.30	4.60	4.70	4.70	6.30	4.60	4.60	4.60	4.60
12	4.60	3.30	3.50	3.30	4.60	4.70	4.70	7.40	4.60	4.70	4.60	4.60
13	3.70	3.30	3.30	3.40	4.60	4.60	4.90	12.20	4.60	4.80	4.60	4.60
14	3.50	3.30	3.30	3.40	4.60	4.90	7.80	11.50	4.70	4.60	4.70	4.90
15	3.30	3.30	3.20	3.30	4.50	11.70	6.10	11.80	4.60	4.60	4.60	12.60
16	3.30	3.30	3.20	3.30	4.50	11.90	4.60	11.30	4.60	4.60	4.60	9.30
17	3.30	3.30	3.20	3.30	5.60	11.80	4.60	12.60	4.60	4.60	4.60	8.20
18	3.30	3.30	3.20	3.30	5.00	11.30	5.30	10.30	4.60	4.60	4.60	4.80
19	3.30	3.20	3.20	3.70	4.90	8.40	4.70	5.10	4.60	4.60	4.60	4.70
20	3.30	3.20	3.20	(a)	4.90	8.60	4.70	4.60	4.60	4.60	4.60	4.60
21	3.30	3.20	3.30	.....	5.30	10.30	4.60	4.60	4.70	4.60	4.60	4.60
22	3.40	3.30	3.30	.....	b14.50	10.40	4.60	4.70	4.70	4.60	4.60	4.60
23	3.40	3.30	3.20	.....	8.00	9.60	4.60	7.30	4.60	4.60	4.70	4.60
24	3.30	3.30	3.20	.....	6.00	8.80	4.60	.....	4.60	4.60	4.80	4.60
25	3.30	3.20	3.30	.....	5.50	8.40	4.70	7.40	4.60	4.60	4.60	4.60
26	3.20	3.20	10.90	.....	5.60	4.80	4.60	4.70	4.60	4.60	4.60	4.60
27	3.20	3.10	9.10	.....	5.60	4.80	4.70	4.70	4.70	4.60	4.60	4.70
28	3.20	3.10	3.70	.....	5.10	5.20	4.60	4.60	4.70	4.60	4.60	5.30
29	3.20	.....	6.80	.....	4.50	8.40	4.70	4.60	4.80	4.60	4.60	12.90
30	3.30	.....	3.40	4.50	4.60	9.90	4.70	4.60	4.70	4.60	4.60	10.20
31	3.30	.....	3.30	.....	4.60	.....	4.60	4.80	.....	4.60	.....	8.40

a Gage carried away; replaced April 30.

b Flood estimated.

Rating table for Yadkin River, at Siloam, N. C., for 1900–1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.7	850	4.3	3,450	6.9	10,180	9.5	16,940
1.8	870	4.4	3,700	7.0	10,440	9.6	17,200
1.9	900	4.5	3,950	7.1	10,700	9.7	17,460
2.0	930	4.6	4,200	7.2	10,960	9.8	17,720
2.1	975	4.7	4,460	7.3	11,220	9.9	17,980
2.2	1,020	4.8	4,720	7.4	11,480	10.0	18,240
2.3	1,070	4.9	4,980	7.5	11,740	10.1	18,500
2.4	1,120	5.0	5,240	7.6	12,000	10.2	18,760
2.5	1,170	5.1	5,500	7.7	12,260	10.3	19,020
2.6	1,220	5.2	5,760	7.8	12,520	10.4	19,280
2.7	1,270	5.3	6,020	7.9	12,780	10.5	19,540
2.8	1,320	5.4	6,280	8.0	13,040	10.6	19,800
2.9	1,370	5.5	6,540	8.1	13,300	10.7	20,060
3.0	1,420	5.6	6,800	8.2	13,560	10.8	20,320
3.1	1,470	5.7	7,060	8.3	13,820	10.9	20,580
3.2	1,540	5.8	7,320	8.4	14,080	11.0	20,840
3.3	1,630	5.9	7,580	8.5	14,340	11.1	21,100
3.4	1,740	6.0	7,840	8.6	14,600	11.2	21,360
3.5	1,880	6.1	8,100	8.7	14,860	11.3	21,620
3.6	2,020	6.2	8,360	8.8	15,120	11.4	21,880
3.7	2,180	6.3	8,620	8.9	15,380	11.5	22,140
3.8	2,350	6.4	8,880	9.0	15,640	11.6	22,400
3.9	2,540	6.5	9,140	9.1	15,900	11.7	22,660
4.0	2,740	6.6	9,400	9.2	16,160	11.8	22,920
4.1	2,960	6.7	9,660	9.3	16,420	11.9	23,180
4.2	3,200	6.8	9,920	9.4	16,680	12.0	23,440

Estimated monthly discharge of Yadkin River at Siloam, N. C.

[Drainage area, 1,219 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	
1900.						*Inches.*
August 3 to 31	.....	.....	1,031	0.85	0.91	2.56
September 1 to 15	.....	.....	937	.77	.44	3.52
October	22,660	1,220	2,295	1.88	2.17	5.62
November	22,920	1,370	3,994	3.28	3.65	.....
December	2,180	1,470	1,538	1.26	1.45	4.11
1901.						
January	4,200	1,540	1,738	1.43	1.65	3.18
February	1,740	1,470	1,614	1.32	1.38	1.45
March	20,580	1,470	2,970	2.40	2.77	5.11
April 1 to 19[a]	.....	.....	1,762	1.45	1.08	8.04
May	29,940	3,950	5,864	4.81	5.54	7.69
June	23,180	3,950	10,329	8.47	9.45	7.79
July	14,600	4,200	5,601	4.59	5.29	5.37
August	25,000	4,200	8,552	7.02	8.09	17.05
September	4,720	4.200	4,295	3.52	3.93	3.98
October	4,720	4,200	4,242	3.48	4.01	1.01
November	4,720	4,200	4,235	3.47	3.88	1.15
December	25,780	4,200	7,211	5.92	6.82	9.94
The year	29,940	1,470	4,868	3.99	53.89	71.76

[a] Gage washed out by flood April 20.

MISCELLANEOUS MEASUREMENTS IN PEDEE OR YADKIN DRAINAGE BASIN.

The following miscellaneous measurement was made in the Pedee or Yadkin drainage basin in 1902:

October 20: Pedee River at S. A. L. R. R. crossing, near Rockingham, N. C., discharge, 3,476 second-feet.

SANTEE RIVER DRAINAGE BASIN.

Santee River is formed by the junction of Congaree and Wateree rivers in the central part of South Carolina, and flows toward the southeast into the Atlantic Ocean about 10 miles north of Cape Romain, having a total length of about 180 miles (following the course of the river) and draining an area of about 15,000 square

miles. It is a navigable stream for its entire length, and of course offers no opportunities for the development of power.

Wateree River, the more northerly of the two parent streams, rises on the eastern slope of the Blue Ridge in McDowell County, N. C., and flows first to the northeast and then to the east, then bends abruptly to the southeast and flows in this general direction across the southern central portion of North Carolina and across the northern central part of South Carolina to its junction with the Congaree, practically paralleling the course of the Yadkin and Pedee rivers. This stream is known throughout its course in North Carolina as Catawba River, and also through that part of its course in South Carolina above the mouth of Wateree Creek. The total length of the stream is about 270 miles in a straight line, and about 450 miles when all the windings are followed.

The Wateree is navigable as far as Camden, but above this point the fall becomes too great and navigation is impracticable. In 1826 and following years the State of South Carolina spent large sums in the attempt to render the river navigable by means of locks and dams. Some large and important works were constructed at great expense, but the undertaking was abandoned before their completion.

The drainage basin resembles that of the Yadkin in many respects, the upper portion of the stream flowing between parallel ranges of mountains from which it receives many tributaries affording much power. The average width of the valley of the main stream in North Carolina is only from 15 to 20 miles, and the fall in the main stream is very considerable. The greater part of the drainage basin is hilly, and the upper portions are mountainous. A number of the tributary streams rise and flow for almost their entire length in high mountains. About 65 per cent of the upper part of the basin is in forest. Linville River and John River, the principal tributaries in North Carolina, flow in country of this character, and their basins are almost entirely forested.

Wateree River crosses the fall line about 5 miles above Camden, S. C., in rapids about 5 miles in length, with a total fall of about 52 feet. The Great Falls of the Catawba are some distance above. This is the largest power in South Carolina, and one of the largest in the Southern States, the available fall being 173 feet.

The average rainfall on the basin is about 50 inches, the annual total increasing as the stream is ascended. The maximum flood ever experienced on the river was in May, 1901, the gage reading at the Rockhill station being 24.15 feet and the measured discharge nearly 151,000 second-feet, or nearly 50 second-feet per square mile from the drainage basin above the station. The greatest flood previously experienced on the stream was in 1865. This was only about 2 feet

lower than the flood of May on the lower part of the river, but the May rise exceeded all previous records on the upper portion of the river by from 8 to 15 feet.

The minimum flow recorded for the Rockhill station is 1,300 second-feet, or about 0.43 second-foot per square mile. The maximum flow is about 116 times the minimum.

The Congaree, the second and more southerly of the two streams which by their union form the Santee, is formed by the junction of Broad and Saluda rivers between Lexington and Richland counties, S. C., whence it flows in a general southeasterly direction, but in a very tortuous channel, for about 60 miles to its junction with the Wateree. The stream is navigable to Columbia, the capital of the State. There it crosses the fall line, giving rise to a very fine water power, the only one on the stream, which is being extensively used in the manufacturing enterprises of Columbia.

Broad River rises on the eastern slope of the Blue Ridge near Hickory Nut Gap, in the southwestern part of McDowell County and the northeastern part of Henderson County, N. C., and flows in a general southeasterly direction across a portion of southern-central North Carolina and of northern-central South Carolina to its junction with the Saluda at Columbia. The length of the river in a straight line is about 128 miles, but it is much greater if the course of the river is followed.

In general character the drainage basin closely resembles those of the Yadkin and the Catawba. It lies entirely above the fall line, is without lakes, and is well wooded, especially in the upper portion, and the soil is generally loose and porous.

The rainfall of the basin averages about 51 inches, of which about 13 inches fall in spring, the same in summer, about 10 in autumn, and about 15 in winter. It is probable that the precipitation in the region about the headwaters is much greater than these amounts indicate.

The maximum flood recorded at the Alston station on this stream, 25 miles above Columbia, occurred in May, 1901, the estimated discharge being 131,000 second-feet, equivalent to about 28 second-feet per square mile. The minimum flow recorded at the same place is 1,660 second-feet, equivalent to 0.36 second-foot per square mile. The maximum flow is therefore about 79 times the minimum.

Saluda River is formed in western South Carolina by the junction of the north, south, and middle forks, and flows southeast to its junction with Broad River, the length of the stream being about 110 miles in a straight line. The three forks are mountain streams, and the character of the drainage basin is similar to that of Broad River.

The average rainfall over the basin of the stream is 51 inches, the amount and seasonal distribution being similar to that on the Broad.

The maximum flood recorded at the Waterloo station on this stream occurred in February, 1902, the rise being 23 feet above low water, and the estimated discharge being about 18,500 second-feet, equivalent to about 18 second-feet per square mile. The minimum discharge so far recorded is 290 second-feet, or about 0.28 second-foot per square mile. The maximum discharge is therefore about 64 times the minimum.

The United States Geological Survey has maintained the following stations in this basin, under the direction of E. W. Myers: On the Catawba, near Rockhill, S. C.; at Catawba, N. C., and near Morgantown, N. C.; on the John, near Morgantown, N. C.; on the Linville, near Bridgewater, N. C.; on the Broad (of the Carolinas), near Alston, S. C.; on the Saluda, near Waterloo, S. C.

CATAWBA RIVER NEAR ROCKHILL, S. C.

This station was established by C. C. Babb on September 3, 1895. It is located at the bridge of the Southern Railway, 3 miles south of Fort Mill, S. C., and is about 60 miles below the Catawba station, now abandoned. The gage, a wire gage of the ordinary type, is fastened to the upstream guard rail on the upper side, the 2-foot mark on the rod being over the center of the second vertical compression member of the second truss from the south end of the bridge. The distance from the zero of the rod to the outside edge of the pulley wheel is 1.3 feet, and from the end of the weight to the pointer on the wire is 52.96 feet.

The length of the gage was frequently verified during 1902 and was found correct. The station is reached from Rockhill by private conveyance. The channel of the stream is curved above and below the bridge, which crosses at the head of a bend. The current flows at an angle with the bridge and is swift; the water is shallow at ordinary stages of the stream, and the bottom rough. Altogether, the station is a poor one. The observer is D. A. Morris, a farmer living near the bridge.

The following discharge measurements were made during 1902 by J. S. Henderson and B. S. Drane:

May 13: Gage height, 2.20 feet; discharge, 4,013 second-feet.
August 8: Gage height, 1.70 feet; discharge, 3,086 second-feet.
August 29: Gage height, 1.62 feet; discharge, 2,504 second-feet.

Daily gage height, in feet, of Catawba River near Rockhill, S. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.50	4.00	15.30	4.10	2.30	2.00	2.20	2.10	1.60	1.90	1.80	4.25
2	4.70	9.00	11.90	3.90	2.30	2.00	2.10	2.10	1.60	2.30	1.75	2.90
3	3.70	6.20	6.30	3.50	2.30	2.00	2.00	2.10	1.60	2.00	1.70	5.60
4	3.40	4.50	5.60	3.10	2.30	2.00	2.00	1.90	2.70	1.80	1.70	5.10
5	3.20	3.40	4.00	3.00	2.30	1.90	1.90	1.90	2.80	1.90	1.70	4.00
6	2.90	3.20	4.00	3.00	2.30	1.90	2.00	1.80	2.40	3.20	1.70	3.60
7	2.90	3.00	4.00	2.90	2.20	2.10	1.90	1.80	1.70	3.10	2.00	3.40
8	2.80	3.00	3.40	3.00	2.20	1.90	1.90	1.70	1.60	2.20	2.45	2.75
9	2.80	2.80	3.50	3.20	2.20	2.20	1.90	1.70	3.20	1.90	2.00	2.50
10	2.80	2.70	3.40	3.10	2.20	2.10	2.40	1.70	5.50	1.80	1.80	2.30
11	2.70	2.60	3.20	2.90	2.20	2.00	2.60	1.70	3.50	1.90	1.80	2.15
12	2.70	2.60	3.00	2.70	2.20	1.90	2.50	2.00	2.40	2.40	1.80	2.15
13	2.70	2.60	3.30	2.60	2.20	1.90	2.50	2.10	1.90	2.20	1.75	2.40
14	2.60	2.60	3.10	2.60	2.20	1.90	2.40	6.00	1.80	2.70	1.70	2.40
15	2.60	2.70	3.00	2.50	2.30	2.00	2.30	3.50	1.60	2.30	1.70	2.30
16	2.60	2.70	3.00	2.50	2.40	6.60	2.20	2.40	1.60	2.00	1.70	2.15
17	2.50	2.70	3.40	2.40	2.30	16.40	2.10	1.85	1.60	1.80	1.70	2.65
18	2.50	2.70	5.30	2.70	2.40	7.40	2.00	1.80	1.60	1.80	6.10	3.20
19	2.50	2.70	3.90	2.60	2.40	4.10	1.90	1.70	1.60	1.60	2.50	2.90
20	2.50	2.70	3.40	2.60	2.60	2.60	1.90	1.70	1.60	1.60	2.60	2.50
21	2.50	2.70	3.10	2.60	2.50	2.50	1.90	1.70	1.60	1.60	2.10	2.30
22	3.20	3.20	3.10	2.60	2.50	2.40	1.90	1.70	1.60	1.60	1.90	3.80
23	2.90	4.70	3.00	2.60	2.50	2.40	2.10	1.70	1.60	1.60	1.90	3.20
24	2.90	4.90	2.90	2.60	2.40	2.40	1.90	1.70	1.60	1.60	1.80	3.00
25	2.50	5.40	2.80	2.50	2.30	2.40	1.90	1.70	1.60	1.60	1.80	2.60
26	2.50	5.80	2.80	2.50	2.70	2.30	2.10	1.60	1.60	1.60	2.40	2.40
27	2.50	6.30	2.80	2.50	2.50	2.20	1.90	1.60	1.60	2.00	2.40	2.25
28	2.60	7.60	2.70	2.40	2.50	2.20	1.90	1.60	1.60	3.80	2.20	2.15
29	2.80	.....	3.80	2.40	2.40	2.20	1.90	1.60	1.60	2.70	2.10	2.10
30	2.90	.....	9.90	2.30	2.10	2.20	2.00	1.60	1.70	2.70	1.80	2.10
31	3.00	.....	6.20	.....	2.00	.....	2.10	1.60	.....	2.00	.....	2.30

Rating table for Catawba River near Rockhill, S. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	2,700	3.2	6,300	4.8	10,800	8.5	26,500
1.8	3,100	3.4	6,800	5.0	11,500	9.0	29,000
2.0	3,550	3.6	7,300	5.5	13,275	9.5	31,500
2.2	4,000	3.8	7,800	6.0	15,250	10.0	34,000
2.4	4,450	4.0	8,300	6.5	17,275	10.5	36,750
2.6	4,900	4.2	8,900	7.0	19,500	11.0	39,500
2.8	5,350	4.4	9,500	7.5	21,750	11.5	42,500
3.0	5,800	4.6	10,100	8.0	24,000	12.0	45,500

Estimated monthly discharge of Catawba River near Rockhill, S. C.

[Drainage area, 2,987 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	21,750	4,675	6,019	2.02	2.33
February	29,000	4,900	8,846	2.96	3.08
March	70,400	5,125	11,724	3.93	4.53
April	8,600	4,225	5,368	1.80	2.01
May	5,125	3,550	4,290	1.44	1.66
June	79,400	3,325	7,580	2.54	2.93
July	4,900	3,325	3,717	1.24	1.43
August	15,250	2,700	3,634	1.22	1.41
September	13,275	2,700	3,651	1.22	1.36
October	7,800	2,700	3,804	1.27	1.46
November	15,650	2,900	3,830	1.28	1.43
December	13,650	3,775	5,686	1.90	2.19
The year	79,400	2,700	5,512	1.90	25.82

CATAWBA RIVER AT CATAWBA, N. C.

This river rises in the western part of North Carolina, flows east, then south to the central part of South Carolina, where it unites with the Congaree to form the Santee River. At a number of points along this river there are water powers which may be developed. Near its source Catawba River flows through a mountainous country, which becomes flatter as the South Carolina line is approached. The greater part of its drainage basin is covered with woodland or forest. The station at Catawba was originally established by E. W. Myers in July, 1896, but was abandoned on December 31, 1899. It was located at the Southern Railway bridge, about one-half mile from Catawba, N. C. The river is straight above and below the bridge; the current is swift and evenly distributed across the stream. The channel is obstructed by three piers. At time of highest water the west bank overflows slightly and the sandy bed cuts out in places. The observer is C. A. Reed, jr., a clerk in the post-office at Catawba, N. C. Discharge measurements were made from the plank walk underneath the bridge. The railway bridge here is a deck bridge, and the gage was located on a footway which was laid along the lower system of bracing. When the station was visited in October, 1899, it was discovered that the span

on which the gage was located was to be removed, so it became necessary to move the gage rod, which was done as follows:

A small temporary gage was installed to discover any change in the stage of the river while the gage was being removed. The distance from the weight to the pointer on the wire was measured and found to be correct when the gage reading was taken and recorded, as was also the reading of the temporary gage. The rod was then moved to the position which was chosen for it and securely fastened to the guard rail on the downstream side and on the second span of the bridge from the west. The zero of the rod is over the center of the second floor beam from the west end of the second span from the west end of the bridge. From the zero of the rod to the outer rim of the pulley wheel is 2.6 feet. The small temporary gage was then read, and it was found that the reading was unchanged; so the gage in its new position was given the same reading which it had before. The length of the wire rope from the end of the weight to the pointer on the wire was then measured and found to be 55.25 feet. On June 13, 1900, the station was reestablished as a temporary station to assist in the study of the hydrography of the southern Appalachian region. The wire gage was suspended from the bridge and was referred to a painted gage rod, which was divided into feet and tenths and nailed to the guard rail. The initial point of sounding was on the west end of the bridge.

The station was again abandoned in April, 1902, as the section had been so badly injured by floods and by repairs to the bridge that it was almost worthless as a point of measurement. The drainage area above this station is 1,535 square miles.

Daily gage height, in feet, of Catawba River at Catawba, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1902.					1902.				
1	.....	3.35	11.80	5.35	17	2.55	2.60	6.50	.....
2	.....	3.35	8.20	4.60	18	2.50	2.60	4.20	.....
3	.....	4.60	6.50	3.85	19	2.50	2.60	3.95	.....
4	.....	4.35	5.25	3.25	20	2.50	2.60	3.80	.....
5	3.25	4.05	4.40	3.00	21	2.50	2.85	3.55	.....
6	3.20	4.05	3.85	3.00	22	2.50	3.60	3.25	.....
7	3.20	3.80	3.60	3.00	23	2.50	3.35	3.10	.....
8	3.15	3.60	3.45	3.20	24	2.50	3.10	3.00	.....
9	3.05	2.85	3.30	3.05	25	2.50	8.20	2.90	.....
10	2.90	2.60	3.15	3.00	26	2.50	6.70	2.85	.....
11	2.80	2.60	3.10	3.00	27	2.50	4.75	2.85	.....
12	2.80	2.60	3.00	.....	28	3.25	19.00	3.90	.....
13	2.75	2.60	3.00	.....	29	4.10	.....	13.25	.....
14	2.70	2.60	3.15	.....	30	3.80	.....	6.70	.....
15	2.70	2.60	4.10	.....	31	3.50	.....	6.10	.....
16	2.60	2.60	4.90	.....					

CATAWBA RIVER NEAR MORGANTON, N. C.

This station was established on June 19, 1900, in connection with the hydrographic investigation of the southern Appalachian area which was then in progress, and was located on the highway bridge on the road from Morganton to Hartland. A wire gage of the usual type was established, with a horizontal scale board graduated to feet and tenths.

The river is straight for a considerable distance below the bridge, but there is a bend of nearly a right angle about 200 to 300 feet above. The banks of the stream are very high, having never been overflowed.

Previous to the establishment of this station the highest known flood in this stream rose to the level of the bridge floor, a height of about 28 feet; but in May, 1901, the river rose throughout this part of its course from 8 to 15 feet higher than ever before known, and the bridge and gage were destroyed.

The bed of the river is of sand and mud, with some loose rock, and will probably shift to a very slight extent during severe floods. This station was maintained only during 1900 and was abandoned at the end of that year.

During 1900 the following discharge measurements were made at this station:

June 13: Gage height, 1.33 feet; discharge, 1,393 second-feet.
June 18: Gage height, 2.50 feet; discharge, 4,030 second-feet.
July 6: Gage height, 1.30 feet; discharge, 1,164 second-feet.
August 8: Gage height, 0.60 foot; discharge, 558 second-feet.
September 24: Gage height, 0.50 foot; discharge, 525 second-feet.
November 7: Gage height, 1.50 feet; discharge, 1,374 second-feet.

Daily gage height, in feet, of Catawba River near Morganton, N. C.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.							
1	.....	1.53	0.97	0.60	0.50	1.25	1.35
2	.....	1.78	.83	.55	.50	1.25	1.25
3	.....	1.60	.78	.60	.58	2.70	1.65
4	.....	1.48	.75	.53	1.00	1.70	2.40
5	.....	1.43	.75	.55	1.20	1.45	2.30
6	.....	1.30	.70	.50	1.10	1.70	1.97
7	.....	1.23	.70	.45	.80	1.55	1.60
8	.....	1.20	.65	.50	.85	1.25	1.45
9	.....	1.10	.63	.45	.80	1.35	1.50
10	.....	1.50	.60	.45	.75	1.20	1.40
11	.....	1.00	.58	.33	.65	1.20	1.25
12	.....	1.00	.57	.35	.60	1.20	1.20
13	.....	1.25	.65	.33	.55	1.10	1.10
14	.....	1.00	.65	1.55	.58	1.25	1.05
15	.....	.95	.63	2.50	.53	1.25	.....

Daily gage height, in feet, of Catawba River near Morganton, N. C.—Continued.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.							
16	.....	0.90	0.55	2.15	0.53	1.25	.....
17	.....	.87	.63	1.25	.53	1.25	.....
18	.....	.87	.63	1.15	.53	1.00	.....
19	2.50	.83	.53	.80	.53	1.50	.....
20	1.60	.85	.45	.68	.53	1.25	.....
21	1.60	.87	.45	.63	.50	1.00	.....
22	3.37	.83	.65	.43	.50	1.50	.....
23	3.05	.80	.73	.55	8.55	.95	.....
24	3.87	.93	.58	.53	6.48	1.50	.....
25	3.60	1.23	.80	.55	4.15	1.90	.....
26	3.00	1.25	.60	.53	2.95	4.30	.....
27	2.30	2.63	.53	.53	1.80	3.20	.....
28	2.28	1.05	.63	.48	1.60	2.30	.....
29	1.95	1.10	.55	.55	1.60	1.60	.....
30	1.70	1.45	.60	.53	1.40	1.52	.....
31	.....	1.43	.55	.....	1.35	.....	.....

Rating table for Catawba River near Morganton, N. C., for 1900.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.3	455	2.2	2,310	4.1	5,470	6.0	8,700
.4	490	2.3	2,470	4.2	5,640	6.5	9,550
.5	525	2.4	2,630	4.3	5,810	7.0	10,400
.6	560	2.5	2,790	4.4	5,980	7.5	11,250
.7	620	2.6	2,950	4.5	6,150	8.0	12,100
.8	690	2.7	3,110	4.6	6,320	8.5	12,950
.9	770	2.8	3,270	4.7	6,490	9.0	13,800
1.0	860	2.9	3,430	4.8	6,660	9.5	14,650
1.1	955	3.0	3,600	4.9	6,830	10.0	15,500
1.2	1,055	3.1	3,770	5.0	7,000	10.5	16,350
1.3	1,160	3.2	3,940	5.1	7,170	11.0	17,200
1.4	1,265	3.3	4,110	5.2	7,340	11.5	18,050
1.5	1,375	3.4	4,280	5.3	7,510	12.0	18,900
1.6	1,485	3.5	4,450	5.4	7,680	12.5	19,750
1.7	1,600	3.6	4,620	5.5	7,850	13.0	20,600
1.8	1,725	3.7	4,790	5.6	8,020	13.5	21,450
1.9	1,860	3.8	4,960	5.7	8,190	14.0	22,300
2.0	2,000	3.9	5,130	5.8	8,360		
2.1	2,150	4.0	5,300	5.9	8,530		

Estimated monthly discharge of Catawba River near Morganton, N. C.

[Drainage area, 758 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall in inches.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	
1900.						
June [a]			2,948	3.89	1.74	9.01
July	3,000	690	1,092	1.440	1.66	4.24
August	815	507	597	.797	.91	1.96
September	2,790	473	734	.96	1.08	4.23
October	13,035	525	1,698	2.24	2.59	9.76
November	5,810	815	1,562	2.06	2.30	.....
December [b]			1,462	1.93	1.00	4.58

[a] 12 days. [b] 14 days.

JOHN RIVER NEAR MORGANTON, N. C.

This station, like the one on the Catawba River near Morganton, was established in connection with the hydrographic investigation of the southern Appalachian area. It was located on the highway bridge on the road from Morganton to Lenoir.

A wire gage was established similar to that at the Morganton station, the gage rod being nailed to the guard rail on the downstream side of the bridge.

The section presented at this station is fairly good at all times, though for a part of the way the bottom is rough and rocky. The river banks are high and are never overflowed, the bed is permanent, and the course of the stream is straight for some distance above and below the station.

This station was abandoned on December 31, 1901.

Discharge measurements of John River near Morganton, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
June 13	E. W. Myers	2.64	465
June 19	do	3.50	1,202
July 6	do	2.63	511
August 8	do	1.90	135
September 24	do	1.90	148
November 7	do	2.32	367

Daily gage height, in feet, of John River near Morganton, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.												
1	.....	.....	.....	.....	.....	.....	.....	2.10	.....	1.80	2.30	2.32
2	.....	.....	.....	.....	.....	.....	2.60	2.03	.....	1.83	2.30	.....
3	.....	.....	.....	.....	.....	.....	2.55	2.00	.....	1.93	2.50	2.32
4	.....	.....	.....	.....	.....	.....	2.58	2.15	.....	2.43	.....	3.38
5	.....	.....	.....	.....	.....	.....	2.70	1.90	.....	2.38	2.60	3.20
6	.....	.....	.....	.....	.....	.....	2.58	1.88	.....	2.28	2.35	2.85
7	.....	.....	.....	.....	.....	.....	2.45	1.93	.....	2.10	2.35	2.67
8	.....	.....	.....	.....	.....	.....	.....	1.90	.....	2.03	2.30	2.62
9	.....	.....	.....	.....	.....	.....	2.38	1.90	.....	1.93	2.25	2.00
10	.....	.....	.....	.....	.....	.....	2.30	1.90	1.70	1.90	2.25	2.50
11	.....	.....	.....	.....	.....	.....	2.25	1.90	1.70	1.90	.....	2.35
12	.....	.....	.....	.....	.....	.....	2.25	.....	1.70	1.95	2.20	2.32
13	.....	.....	.....	.....	.....	.....	2.30	1.98	1.70	1.90	2.20	2.35
14	.....	.....	.....	.....	.....	.....	2.25	1.88	1.80	.....	2.15	2.30
15	.....	.....	.....	.....	.....	.....	.....	1.93	2.90	1.90	2.15	2.28
16	.....	.....	.....	.....	.....	.....	2.15	1.93	.....	1.88	2.10	.....
17	.....	.....	.....	.....	.....	.....	2.13	1.93	2.30	1.83	2.05	2.25
18	.....	.....	.....	.....	.....	.....	2.10	1.93	2.03	1.78	.....	2.20
19	.....	.....	.....	.....	.....	3.50	2.10	.....	1.95	1.73	2.12	2.18
20	.....	.....	.....	.....	.....	3.25	2.15	.....	1.90	1.73	2.15	2.22
21	.....	.....	.....	.....	.....	2.80	2.45	.....	1.90	.....	2.12	3.08
22	.....	.....	.....	.....	.....	3.28	.....	.....	1.90	1.88	2.10	2.92
23	.....	.....	.....	.....	.....	3.20	2.10	.....	.....	14.72	2.08	.....
24	.....	.....	.....	.....	.....	.....	2.28	.....	1.90	5.60	2.08	2.78
25	.....	.....	.....	.....	.....	3.75	2.35	.....	1.85	3.45	.....	2.68
26	.....	.....	.....	.....	.....	3.58	2.30	.....	1.83	2.98	4.55	2.48
27	.....	.....	.....	.....	.....	3.23	2.23	.....	1.83	2.70	3.00	2.32
28	.....	.....	.....	.....	.....	3.20	2.20	.....	1.80	.....	2.65	2.32
29	.....	.....	.....	.....	.....	2.95	.....	.....	1.83	2.45	2.52	2.28
30	.....	.....	.....	.....	.....	2.85	2.20	.....	.....	2.30	2.42	.....
31	.....	.....	.....	.....	.....	.....	2.13	.....	.....	2.30	.....	2.90
1901.												
1	2.62	2.23	2.20	3.05	2.95	3.63	3.45	2.60	5.15	3.08	2.52	2.35
2	2.52	2.28	2.15	8.85	2.90	.....	3.30	2.50	4.05	3.00	2.53	2.40
3	2.42	.....	.....	8.20	2.90	3.42	3.15	2.40	3.90	2.90	2.53	2.43
4	2.32	2.65	2.15	4.15	2.80	3.33	3.10	.....	3.80	2.80	2.53	2.43
5	2.30	2.33	2.13	3.90	.....	3.25	3.00	2.60	3.60	2.75	2.53	2.33
6	2.32	2.33	2.13	3.25	2.80	3.50	3.00	17.02	3.50	2.70	2.53	2.33
7	2.32	2.33	2.13	.....	2.73	3.70	.....	6.00	3.40	2.70	2.53	2.33
8	2.32	2.28	2.13	3.18	3.85	3.45	3.00	3.85	3.20	2.73	2.53	2.35
9	2.32	2.53	2.08	2.95	3.05	.....	3.00	3.38	3.20	2.72	2.53	2.40
10	2.37	.....	.....	2.70	3.08	3.13	2.93	3.05	3.20	2.70	2.53	3.50
11	2.80	2.43	3.25	2.68	3.05	3.08	2.90	.....	3.17	2.70	2.53	3.10
12	5.65	2.43	2.45	2.60	.....	3.00	2.95	3.27	3.17	2.68	2.50	2.90
13	.....	2.38	2.33	2.70	2.78	2.90	3.00	4.35	3.10	2.70	2.53	2.80
14	3.02	2.33	2.30	.....	2.70	8.95	.....	6.10	3.08	2.95	2.50	3.10
15	2.88	2.35	2.28	2.85	2.70	4.60	2.95	10.30	.....	2.80	2.50	19.00
16	2.68	2.35	2.25	2.68	2.63	.....	3.25	5.75	3.60	2.78	2.45	6.58
17	2.58	.....	.....	2.60	2.57	5.55	3.05	5.00	3.15	2.72	2.47	4.70
18	2.50	2.30	2.23	2.70	2.50	4.35	2.90	.....	3.10	2.68	2.48	3.75
19	2.48	2.33	2.20	5.20	.....	3.92	3.15	5.15	3.00	2.65	2.47	3.05
20	.....	2.28	2.20	17.70	3.18	4.45	3.05	4.48	3.00	2.60	2.48	2.95
21	2.43	2.28	2.72	6.60	10.25	4.27	.....	4.50	2.95	2.60	2.42	2.87
22	2.43	2.28	2.32	4.60	20.50	7.90	2.77	7.15	.....	2.60	2.43	.....

Daily gage height, in feet, of John River near Morganton, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
23	2.40	2.23	2.25	4.15	6.15	.....	2.70	6.11	2.90	2.60	2.47	2.90
24	2.33	.....	.....	3.70	4.80	4.70	2.70	4.40	2.87	2.55	2.50	2.90
25	2.33	2.20	2.90	3.53	4.40	4.15	2.63	.....	2.88	2.55	2.50	3.00
26	2.30	2.23	13.60	3.38	.....	3.80	2.60	4.55	2.80	2.50	2.43	3.42
27	.....	2.23	6.15	3.27	6.55	3.65	2.57	4.60	2.70	2.50	2.42	2.90
28	2.28	2.23	4.05	.....	5.00	3.60	.....	4.48	3.60	2.53	2.35	2.85
29	2.28	.....	3.35	3.08	4.20	3.50	2.60	4.43	3.10	2.50	2.38	15.00
30	2.33	.....	3.75	3.00	3.90	.....	8.60	6.15	3.15	2.55	2.30	9.00
31	2.33	.....	.....	.....	.....	.....	2.73	5.90	.....	2.50	.....	6.45

Rating table for John River near Morganton, N. C., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.7	80	3.6	1,075	5.5	2,215	7.4	3,355
1.8	110	3.7	1,135	5.6	2,275	7.5	3,415
1.9	140	3.8	1,195	5.7	2,335	7.6	3,475
2.0	185	3.9	1,255	5.8	2,395	7.7	3,535
2.1	233	4.0	1,315	5.9	2,455	7.8	3,595
2.2	281	4.1	1,375	6.0	2,515	7.9	3,655
2.3	329	4.2	1,435	6.1	2,575	8.0	3,715
2.4	377	4.3	1,495	6.2	2,635	8.1	3,775
2.5	425	4.4	1,555	6.3	2,695	8.2	3,835
2.6	475	4.5	1,615	6.4	2,755	8.3	3,895
2.7	535	4.6	1,675	6.5	2,815	8.4	3,955
2.8	595	4.7	1,735	6.6	2,875	8.5	4,015
2.9	655	4.8	1,795	6.7	2,935	8.6	4,075
3.0	715	4.9	1,855	6.8	2,995	8.7	4,135
3.1	775	5.0	1,915	6.9	3,055	8.8	4,195
3.2	835	5.1	1,975	7.0	3,115	8.9	4,255
3.3	895	5.2	2,035	7.1	3,175	9.0	4,315
3.4	955	5.3	2,095	7.2	3,235		
3.5	1,015	5.4	2,155	7.3	3,295		

Estimated monthly discharge of John River near Morganton, N. C.

[Drainage area, 213 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	
1900.						*Inches.*
June [a]	.....	.....	869	4.08	1.82	8.26
July	535	233	330	1.55	1.79	4.95
August [b]	.....	.....	169	.79	.53	1.22
September [c]	.....	.....	177	.83	.65	2.49
October	7,735	95	567	2.71	3.13	9.83
November	1,645	209	391	1.84	2.05	.....
December	955	281	455	2.14	2.47	4.74
1901.						
January	2,305	329	502	2.36	2.72	3.09
February	505	281	352	1.65	1.72	2.26
March	6,075	233	709	3.33	3.71	6.77
April	9,535	475	1,447	6.79	7.59	9.21
May	11,215	425	1,485	6.97	8.04	9.28
June	4,285	655	1,426	6.69	7.47	9.13
July	4,075	450	783	3.68	4.24	1.80
August	9,115	377	1,923	9.03	10.40	19.44
September	2,005	535	853	4.00	4.46	4.35
October	775	425	531	2.49	2.87	.97
November	450	329	419	1.97	2.19	.87
December	10,315	353	1,458	6.48	7.48	8.42
The year	11,215	233	991	4.62	62.89	75.59

[a] 12 days. [b] 18 days. [c] 21 days.

LINVILLE RIVER NEAR BRIDGEWATER, N. C.

This station, one of the temporary stations established in connection with the hydrographic investigations of the southern Appalachian region, was established on July 3, 1900, and was located at Poole's mill, just above the ford on the road from Morganton to Marion, the gage being near the tailrace of the mill. The gagings were made about 200 feet below the site of the gage.

Owing to the construction of the gage it was placed so that a rise in the stage of the water surface was indicated by a decrease in the recorded figures, and vice versa, the effect being the same as if the stage of the water surface had been determined by direct measurement down from a fixed point, the gage being placed upside down.

This peculiarity of the gage was not noted in the previous publication of the gage heights and discharge measurements in Water-Supply Paper No. 48, page 142; but the gage heights here given are rectified by subtracting each reading from 12 feet, the rod being 12 feet long, and the rating table for this station is made out for the rectified gage heights.

The bed of the river is extremely rough and rocky throughout its entire course, and a section perfectly suitable for making discharge measurements could not be discovered. There are no bridges, so that it was necessary to make the gagings by wading, and as the rise is considerable and the current velocity very great at high water no measurements of flood discharge were possible.

The bench mark to which the gage was referred is a cross cut in the rock cliff on the left bank of the stream, at the point of gaging; and the initial point of sounding was the end of a log which is sunk in the sand of the right bank. The drainage area above this station is rough, mountainous, and largely forest covered.

Discharge measurements of Linville River near Bridgewater, N. C.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1900.	*Feet.*	*Second-feet.*	1900.	*Feet.*	*Sec.-feet.*
June 14	2.08	104	August 17	1.85	78
July 3	2.46	216	September 21	2.20	55
July 10	2.10	116			

Daily gage height, in feet, of Linville River near Bridgewater, N. C.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1900.					1900.				
1	.....	2.17	1.83	2.25	17	2.17	1.87	2.33	.....
2	.....	2.08	1.83	2.33	18	2.17	1.87	2.33	.....
3	2.46	2.12	1.79	2.42	19	1.96	1.92	2.00	.....
4	2.64	2.17	1.79	2.50	20	2.00	1.92	2.00	.....
5	2.42	2.08	1.75	2.42	21	2.25	1.87	2.08	.....
6	2.46	1.92	1.75	2.42	22	2.08	1.83	2.08	.....
7	2.37	2.00	1.75	2.37	23	2.08	1.83	2.08	.....
8	2.42	1.92	1.71	2.37	24	2.08	1.83	2.08	.....
9	2.29	1.92	1.71	2.37	25	2.17	1.79	2.00	.....
10	2.42	1.92	1.71	2.37	26	2.08	1.83	1.92	.....
11	2.37	1.92	1.71	2.42	27	2.25	1.79	1.92	.....
12	2.33	1.92	1.67	2.50	28	2.25	1.79	1.87	.....
13	2.37	1.92	1.67	2.56	29	2.08	1.79	2.25	.....
14	2.33	1.87	1.71	2.56	30	2.17	1.79	2.25	.....
15	2.29	1.92	1.79	.....	31	2.08	1.79	.....	.....
16	2.33	1.92	4.50	.....					

Rating table for Linville River near Bridgewater, N. C., for 1900.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	55	2.4	194	3.2	515	4.0	835
1.7	63	2.5	235	3.3	555	4.1	875
1.8	78	2.6	275	3.4	595	4.2	915
1.9	84	2.7	315	3.5	635	4.3	955
2.0	97	2.8	355	3.6	675	4.4	995
2.1	112	2.9	395	3.7	715	4.5	1,035
2.2	132	3.0	435	3.8	755		
2.3	160	3.1	475	3.9	795		

Estimated monthly discharge of Linville River near Bridgewater, N. C.

[Drainage area, 86 square miles.]

Month.	Discharge in second-feet.			Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.	
1900.						*Inches.*
July	295	90	154	1.79	2.06	3.75
August	122	73	83	.96	1.11	3.20
September	1,035	59	122	1.41	1.57	2.79
October[a]			191	2.22	1.16	11.54

[a] Fourteen days' record.

BROAD RIVER (OF THE CAROLINAS) NEAR ALSTON, S. C.

This station was established by E. W. Myers on July 3, 1896, and is located at the Southern Railway bridge, near Alston, S. C., about 25 miles above Columbia. The length of the wire gage is 42.65 feet. The section here is not a good one, being broken by the foundations of an old bridge crossing at the same place as the present one. The bed is flat, muddy, and somewhat shifting. The river is straight for a long distance above and below the station. The current is swift and the velocity fairly uniform across the section. The observer is G. M. Heron, a farmer, of Alston, S. C.

The following discharge measurements were made during 1902 by B. S. Drane:

June 14: Gage height, 2.60 feet; discharge, 4,224 second-feet.
July 19: Gage height, 3.40 feet; discharge, 3,757 second-feet.
August 9: Gage height, 3.10 feet; discharge, 3,143 second-feet.

Daily gage height, in feet, of Broad River near Alston, S. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	15.32	13.70	19.55	7.30	4.75	3.70	3.65	3.65	3.15	4.25	3.80	10.80
2	9.50	21.17	20.30	6.50	4.85	3.25	3.45	4.15	3.05	4.20	3.80	7.53
3	7.10	20.88	16.15	6.08	4.60	4.10	3.25	3.70	3.05	3.40	3.60	13.28
4	6.45	14.07	9.98	5.90	5.15	3.65	3.25	4.20	2.95	3.30	3.40	12.13
5	5.90	8.70	7.82	5.75	4.70	3.55	3.45	3.40	4.70	4.10	3.60	8.90
6	5.40	6.50	7.07	5.70	4.50	3.40	3.25	3.60	4.55	4.90	3.50	7.40
7	5.40	6.10	6.60	5.40	4.40	3.35	3.30	3.35	3.40	5.90	4.90	6.35
8	5.30	5.80	6.10	6.20	4.40	4.10	2.90	3.30	3.20	4.60	4.70	5.50
9	5.20	5.50	6.40	6.05	4.35	3.87	3.55	3.10	3.45	3.80	4.10	5.00
10	5.05	5.15	6.25	5.60	4.25	3.55	3.80	3.25	10.35	3.60	3.90	4.65
11	4.90	5.10	5.95	5.30	4.35	3.45	3.75	3.50	9.00	4.90	3.40	4.55
12	4.85	5.00	5.75	5.20	5.05	3.30	4.15	3.15	5.10	4.30	3.80	4.10
13	4.55	4.90	5.85	5.20	4.15	3.25	4.15	3.45	4.05	4.90	3.50	6.15
14	4.45	4.80	6.35	5.15	4.20	2.40	4.25	3.20	3.75	4.40	3.45	4.55
15	4.55	4.70	5.70	5.05	4.05	4.35	3.75	4.65	3.45	5.10	3.40	4.40
16	4.50	4.90	7.50	5.15	4.70	10.23	4.40	5.05	3.20	4.30	3.55	4.30
17	4.70	5.45	12.25	5.25	4.15	14.67	3.90	5.05	3.30	3.90	3.60	5.35
18	4.50	5.15	10.98	6.10	4.45	9.55	3.60	3.95	3.20	3.60	4.50	7.20
19	4.40	5.20	7.85	5.70	4.45	5.80	3.45	3.20	3.20	3.00	5.50	6.00
20	4.45	5.30	6.75	7.55	4.90	4.55	3.35	3.15	3.10	3.70	4.60	6.20
21	4.70	5.75	6.35	6.00	5.70	4.35	3.45	3.00	3.45	3.40	4.05	4.80
22	6.35	8.35	6.10	5.55	4.25	4.35	2.95	2.95	3.35	3.50	3.95	9.65
23	5.60	9.60	5.90	5.25	4.25	4.15	3.70	3.15	3.10	3.70	3.95	7.70
24	5.00	8.50	5.70	5.10	4.05	4.55	3.35	3.85	3.20	3.30	3.70	6.05
25	4.75	9.00	5.50	5.05	4.10	4.75	4.25	3.45	3.05	3.40	3.30	5.30
26	4.70	11.35	5.50	4.90	4.15	4.00	4.15	3.05	3.10	3.40	7.13	4.95
27	4.50	8.80	5.35	4.85	4.25	4.57	3.40	3.15	3.25	3.40	5.80	4.70
28	4.70	13.90	5.60	4.75	3.85	5.20	3.85	3.15	3.80	12.60	4.75	4.30
29	7.45	.....	7.15	4.70	3.75	4.35	3.85	3.90	3.55	7.60	4.15	4.25
30	6.80	.....	12.77	4.75	3.70	3.75	4.25	3.55	3.25	4.40	3.90	5.20
31	10.75	.....	10.15	.....	3.60	.....	4.15	3.25	.....	4.20	.....	4.90

Rating table for Broad River near Alston, S. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.4	2,010	4.4	5,760	8.5	18,000	13.5	37,875
2.6	2,340	4.6	6,320	9.0	19,500	14.0	40,500
2.8	2,670	4.8	6,900	9.5	21,000	14.5	43,125
3.0	3,000	5.0	7,500	10.0	22,500	15.0	45,750
3.2	3,340	5.5	9,000	10.5	24,250	16.0	52,500
3.4	3,680	6.0	10,500	11.0	26,250	17.0	60,750
3.6	4,020	6.5	12,000	11.5	28,500	18.0	70,000
3.8	4,360	7.0	13,500	12.0	30,750	19.0	79,250
4.0	4,730	7.5	15,000	12.5	33,000	20.0	88,500
4.2	5,200	8.0	16,500	13.0	35,250		

Estimated monthly discharge of Broad River near Alston, S. C.

[Drainage area, 4,609 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	47,910	5,760	10,424	2.26	2.61
February	99,323	6,610	21,190	4.60	4.79
March	91,275	8,550	20,322	4.41	5.08
April	15,150	6,610	9,204	2.00	2.23
May	9,600	4,020	5,798	1.26	1.45
June	44,018	2,010	7,413	1.61	1.80
July	5,760	2,835	4,200	.91	1.05
August	7,650	2,917	4,067	.88	1.01
September	23,725	2,917	5,060	1.10	1.23
October	33,450	3,000	6,305	1.37	1.58
November	13,890	3,510	5,275	1.14	1.27
December	36,720	4,965	11,737	2.55	2.94
The year	99,323	2,010	9,250	2.01	27.04

SALUDA RIVER NEAR WATERLOO, S. C.

Saluda River rises in the mountains between North and South Carolina, flows in a southeasterly direction, and unites, near Columbia, S. C., with the Broad, to form the Congaree. Measurements have been made on the Saluda to determine the available water power. The station was established by E. W. Myers on August 30, 1896. It is 1 mile below the mouth of Reedy River, at the Charleston and Western Carolina Railway bridge, about 3 miles from Coronaca station, South Carolina. The river is straight for several hundred yards above and below the bridge. The flow is probably influenced by dams some miles above. The bed of the stream is of sand and mud and liable to change during high water. The banks are low, the right bank being subject to overflow. The observer is R. N. Cunningham, storekeeper and farmer at Waterloo, S. C. The locality is reached by private conveyance from Greenwood, S. C. The discharge measurements are made from the railraod bridge.

The gage was changed July 20, 1902, so that the readings are 1.5 feet higher. The following table of 1902 gage heights gives the heights on the new gage:

The following discharge measurements were made during 1902 by J. S. Henderson and B. S. Drane:

June 14: Gage height, 5.60 feet; discharge, 745 second-feet.
July 19: Gage height, 5.47 feet; discharge, 845 second-feet.
August 9: Gage height, 5.32 feet; discharge, 844 second-feet.
August 25: Gage height, 4.80 feet; discharge, 487 second-feet.

Daily gage height, in feet, of Saluda River near Waterloo, S. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	12.50	18.85	21.10	8.90	6.90	7.15	5.75	6.65	5.05	6.85	6.65	8.50
2	9.70	24.90	19.45	8.45	6.80	5.05	6.75	6.60	5.40	5.90	5.60	7.65
3	9.10	19.60	13.10	8.25	6.90	5.70	5.60	6.75	6.20	5.70	5.50	13.15
4	8.80	12.75	10.40	8.15	8.10	5.55	5.30	5.05	6.45	6.60	6.50	12.10
5	8.45	9.65	9.70	8.10	5.50	5.45	5.65	6.40	5.60	7.40	5.80	9.85
6	7.85	8.90	9.10	8.95	6.40	5.45	5.85	6.40	6.40	7.75	6.35	8.75
7	7.85	8.60	8.85	6.75	6.30	6.65	5.45	5.25	5.30	6.80	5.80	7.75
8	7.30	8.15	8.60	8.05	6.35	6.65	5.50	5.25	5.35	6.65	6.80	7.35
9	7.55	7.95	8.95	7.85	6.25	5.00	6.85	5.30	8.85	6.65	6.00	6.70
10	7.35	7.90	8.55	7.65	7.15	5.85	5.80	6.00	12.20	5.75	6.05	6.60
11	7.45	7.50	8.10	7.55	7.75	5.45	6.05	4.50	8.40	6.50	5.60	6.80
12	7.80	7.25	8.15	7.45	6.10	5.35	6.15	5.20	6.25	6.70	6.60	6.90
13	7.10	7.25	9.40	7.65	7.00	5.35	8.00	5.30	6.70	5.80	5.70	7.45
14	6.95	7.15	8.40	7.30	6.60	6.55	5.50	5.35	5.50	6.10	5.70	7.20
15	6.80	7.20	8.15	7.20	6.40	7.50	5.70	5.25	5.45	6.90	6.60	6.10
16	6.75	7.25	12.85	7.20	6.40	13.05	7.90	5.70	6.50	5.95	5.85	6.35
17	6.70	7.30	14.00	7.30	6.85	11.85	6.25	6.75	5.85	5.90	5.20	8.70
18	6.65	7.50	10.95	7.70	7.20	7.00	5.50	5.05	6.30	6.55	6.00	9.30
19	7.50	7.40	9.20	7.60	6.15	6.40	6.00	5.25	6.45	5.80	6.20	7.70
20	6.25	7.70	8.60	8.35	7.50	6.20	6.80	5.25	7.05	5.85	6.60	7.15
21	7.30	8.90	8.45	7.40	6.90	6.90	5.00	5.30	5.95	5.60	5.75	7.75
22	7.40	9.20	8.20	7.20	6.05	6.65	6.07	5.10	5.85	5.70	6.55	9.65
23	7.10	9.00	8.80	6.65	5.95	6.70	5.30	6.05	6.50	5.65	5.95	8.80
24	6.60	8.70	6.95	7.35	6.90	5.80	5.40	6.80	6.55	5.65	5.50	7.65
25	6.80	9.30	8.00	6.90	7.20	5.95	5.25	4.80	5.75	6.40	5.80	7.45
26	7.40	8.80	7.95	6.60	5.05	5.80	6.30	6.25	7.00	5.80	7.40	7.20
27	6.20	8.20	7.65	6.75	5.80	7.35	5.15	5.40	7.30	8.20	7.00	6.75
28	6.95	23.15	7.60	5.75	5.65	7.25	7.70	5.85	8.15	7.00	6.00	6.40
29	8.15	.....	11.60	6.50	5.65	6.45	7.90	5.70	5.05	6.95	6.45	6.45
30	7.80	.....	12.10	6.50	5.55	5.65	6.20	5.50	5.70	6.80	8.55	6.75
31	11.60	.....	10.10	.....	6.10	.....	5.65	6.25	.....	5.95	.....	7.05

Rating table for Saluda River near Waterloo, S. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.4	320	8.0	2,250	11.6	5,245	17.0	10,600
4.6	400	8.2	2,400	11.8	5,435	17.5	11,100
4.8	485	8.4	2,550	12.0	5,625	18.0	11,600
5.0	571	8.6	2,705	12.2	5,815	18.5	12,100
5.2	657	8.8	2,865	12.4	6,005	19.0	12,600
5.4	751	9.0	3,025	12.6	6,200	19.5	13,100
5.6	850	9.2	3,195	12.8	6,400	20.0	13,600
5.8	950	9.4	3,365	13.0	6,600	20.5	14,100
6.0	1,050	9.6	3,535	13.2	6,800	21.0	14,600
6.2	1,154	9.8	3,705	13.4	7,000	21.5	15,100
6.4	1,260	10.0	3,875	13.6	7,200	22.0	15,600
6.6	1,372	10.2	4,045	13.8	7,400	22.5	16,100
6.8	1,486	10.4	4,215	14.0	7,600	23.0	16,600
7.0	1,600	10.6	4,385	14.5	8,100	23.5	17,100
7.2	1,720	10.8	4,555	15.0	8,600	24.0	17,600
7.4	1,840	11.0	4,725	15.5	9,100	24.5	18,100
7.6	1,970	11.2	4,895	16.0	9,600	25.0	18,600
7.8	2,110	11.4	5,065	16.5	10,100		

Estimated monthly discharge of Saluda River near Waterloo, S. C.

[Drainage area, 1,056 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	6,100	1,154	2,148	2.03	2.34
February	18,500	1,690	4,352	4.12	4.29
March	14,700	1,571	4,098	3.88	4.47
April	2,945	925	1,919	1.82	2.03
May	2,325	592	1,333	1.26	1.45
June	6,650	571	1,485	1.41	1.57
July	2,250	571	1,099	1.04	1.20
August	1,486	360	905	.86	.99
September	5,815	592	1,400	1.33	1.48
October	2,400	850	1,269	1.20	1.38
November	2,665	657	1,173	1.11	1.24
December	6,750	1,102	2,268	2.15	2.48
The year	18,500	360	1,954	1.85	24.92

SAVANNAH RIVER DRAINAGE BASIN.

Savannah River is formed by Tugaloo and Seneca rivers, which unite about 100 miles above Augusta. It flows in a southerly direction, forming a portion of the boundary between South Carolina and Georgia, and empties into the Atlantic Ocean at Savannah, Ga.

The Tugaloo River is formed by Tallulah and Chatooga rivers, which unite near Tallulah Falls, in the northeastern part of Georgia. It also forms a portion of the boundary between South Carolina and Georgia. Broad River is formed by the junction of the North and Middle forks, in northeastern Georgia. After uniting with South Fork near Carlton, Ga., it flows east into Savannah River.

The United States Geological Survey during 1902 maintained the following stations in this basin, under the direction of B. M. Hall: On the Savannah, at Augusta and Calhoun Falls; on the Broad (of Georgia), at Carlton.

SAVANNAH RIVER AT AUGUSTA, GA.

Observations of river height have been maintained since 1875 by the city of Augusta at the city highway bridge. The results have been printed in a volume entitled Stages of Water at River Stations, prepared by the United States Weather Bureau. Those for 1875 to 1889 are given in part 3, those for 1890 to 1892 in part 4, and those for 1893 to 1895 in part 5 of this publication. The gage consists of a vertical timber fastened to the pier and graduated to feet and inches. Readings are made four times a day by J. M. Youngblood, keeper of the city bridge, usually at 6 a. m., 12 m., 6 p. m., and 9 p. m. The 6 a. m. readings are those used by the Weather Bureau, but in the publications of the United States Geological Survey from 1900 to the present, inclusive, the average of all four of the daily readings is used and is reduced to feet and tenths of feet.

Discharge measurements are made at North Augusta highway bridge, which is a through iron bridge in three spans, 206½ feet, 209 feet, and 206½ feet in length, respectively, not including approaches from street to each end. There are two piers in the water and one on each bank. The stream at gage height 6.67 is 572 feet wide, including the two piers. It has a maximum depth of 10 feet and an average depth of 6.5 feet, the mean velocity being 1.24 feet per second. The initial point is the center of the first sidewalk floor beam at the right bank on the downstream side of the bridge.

Bench mark No. 1 is the top of the second iron floor beam from the right bank, downstream side; it corresponds to a gage height of 48.60 feet. Bench mark No. 2 is the top of the plank guard rail at the same point; it corresponds to a gage height of 50.97 feet.

The channel is straight and without obstructions. The banks are moderately high, but are liable to overflow at highest floods. The bed is fairly constant. The observer is paid by the city of Augusta.

The following discharge measurements were made during 1902:

June 20: Gage height, 8.85 feet; discharge, 7,497 second-feet.
July 25: Gage height, 7.85 feet; discharge, 5,246 second-feet.
September 5: Gage height, 7.90 feet; discharge, 5,239 second-feet.

Daily gage height, in feet, of Savannah River at Augusta, Ga., for 1902.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	23.90	19.30	33.80	18.60	9.80	8.30	7.30	7.80	7.70	8.70	7.50	11.80
2	16.60	29.50	33.30	14.50	10.60	8.50	7.20	8.10	7.40	9.90	7.20	13.20
3	13.60	32.40	28.60	13.10	10.80	8.90	7.10	9.00	7.30	9.20	7.10	17.40
4	12.40	28.50	21.50	12.80	10.20	8.50	7.00	8.50	7.20	8.50	7.30	21.10
5	11.50	21.10	17.40	12.50	9.90	8.40	6.90	7.80	7.80	9.20	7.10	17.40
6	11.00	15.60	15.10	12.00	9.80	8.30	6.80	7.70	7.70	10.90	7.40	14.30
7	10.50	13.20	13.90	12.00	9.70	8.30	6.90	7.70	7.10	10.30	7.50	11.80
8	10.50	12.20	13.20	13.40	9.40	8.50	7.00	7.60	7.10	8.70	9.20	10.50
9	10.40	11.60	12.70	13.60	9.60	8.80	7.40	7.20	7.10	8.30	8.30	9.50
10	10.20	11.00	13.10	12.30	10.10	8.60	8.00	7.10	12.30	8.10	8.00	9.10
11	9.90	10.70	12.50	11.60	10.60	8.10	8.00	7.40	13.10	8.00	7.50	9.00
12	9.80	10.40	12.30	11.10	9.60	8.10	8.30	8.60	9.90	8.00	7.40	8.90
13	9.60	10.20	12.30	10.60	9.10	8.10	9.60	8.80	8.30	8.80	7.50	10.70
14	9.40	10.20	13.70	11.10	9.10	8.10	9.40	8.00	7.70	9.40	7.40	10.60
15	9.30	10.30	13.50	10.60	9.70	8.40	8.70	9.50	8.90	8.90	7.30	9.70
16	9.40	10.70	18.50	10.80	9.40	13.00	10.00	10.40	8.00	9.20	7.20	8.90
17	9.20	11,40	27.90	11.20	9.30	15.00	9.20	9.40	7.70	8.40	7.40	9.20
18	9.20	11.10	25.60	13.10	9.20	11.40	8.70	9.20	7.40	8.00	8.00	14.00
19	9.20	10.90	19.50	13.40	9.20	10.40	7.60	8.30	7.40	7.30	8.70	11.50
20	9.20	10.60	16.00	12.70	9.20	9.40	7.10	8.90	8.00	7.50	8.80	10.20
21	9.50	11.80	13.80	12.10	9.20	9.30	6.90	8.10	9.20	7.90	8.00	9.40
22	10.20	14.50	13.10	11.10	9.40	8.90	6.90	7.30	8.40	7.40	7.90	12.20
23	10.20	13.70	12.50	10.70	9.50	8.60	6.90	7.40	8.10	7.20	7.40	14.60
24	9.70	12.60	12.40	10.50	9.20	8.50	7.00	7.40	7.80	7.20	7.50	12.20
25	9.50	16.70	11.90	10.20	8.90	8.40	7.50	7.30	7.90	7.20	7.70	10.40
26	9.30	18.10	12.00	10.20	8.80	8.30	7.60	7.40	13.60	7.00	10.10	9.90
27	9.30	16.20	11.60	10.00	8.60	7.90	7.60	7.40	13.80	7.40	12.40	9.40
28	9.20	25.50	11.90	10.10	8.50	7.80	7.00	7.40	12.80	8.90	10.80	8.90
29	9.90	.....	19.60	9.80	8.40	7.50	7.00	8.70	10.90	8.90	9.10	8.60
30	11.60	.....	28.20	9.90	8.30	7.60	7.80	8.40	9.30	8.20	8.40	8.90
31	11.40	.....	24.60	.....	8.20	.....	8.00	7.50	.....	7.80	.....	9.70

Rating table for Savannah River at Augusta, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.8	3,400	10.8	11,200	14.8	19,660	23.0	45,800
7.0	3,740	11.0	11,600	15.0	20,100	23.5	48,900
7.2	4,100	11.2	12,020	15.2	20,560	24.0	52,000
7.4	4,460	11.4	12,440	15.4	21,020	24.5	56,000
7.6	4,840	11.6	12,860	15.6	21,480	25.0	60,000
7.8	5,220	11.8	13,280	15.8	21,940	25.5	64,400
8.0	5,600	12.0	13,700	16.0	22,400	26.0	68,800
8.2	6,000	12.2	14,120	16.5	23,600	26.5	73,200
8.4	6,400	12.4	14,540	17.0	24,800	27.0	77,600
8.6	6,800	12.6	14,960	17.5	26,050	27.5	82,000
8.8	7,200	12.8	15,380	18.0	27,300	28.0	86,400
9.0	7,600	13.0	15,800	18.5	28,700	28.5	90,800
9.2	8,000	13.2	16,220	19.0	30,100	29.0	95,200
9.4	8,400	13.4	16,640	19.5	31,700	29.5	99,600
9.6	8,800	13.6	17,060	20.0	33,300	30.0	104,000
9.8	9,200	13.8	17,480	20.5	35,100	30.5	108,400
10.0	9,600	14.0	17,900	21.0	36,900	31.0	112,800
10.2	10,000	14.2	18,340	21.5	38,950	31.5	117,200
10.4	10,400	14.4	18,780	22.0	41,000	32.0	121,600
10.6	10,800	14.6	19,220	22.5	43,400	33.0	130,400

Estimated monthly discharge of Savannah River at Augusta, Ga.

[Drainage area, 7,294 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	51,380	8,000	11,689	1.60	1.84
February	125,120	10,000	27,595	3.78	3.94
March	137,440	12,860	36,025	4.94	5.69
April	28,980	9,200	13,466	1.85	2.06
May	11,200	6,000	8,394	1.15	1.33
June	20,100	4,650	7,489	1.03	1.15
July	9,600	3,400	5,059	.69	.80
August	10,400	3,920	5,843	.80	.92
September	17,480	3,920	7,458	1.02	1.14
October	11,400	3,740	6,423	.88	1.01
November	14,540	3,920	5,851	.80	.89
December	37,310	6,800	12,700	1.74	2.01
The year	137,440	3,400	12,333	1.69	22.78

SAVANNAH RIVER NEAR CALHOUN FALLS, S. C.

Savannah River is formed by the junction of Seneca and Tugalo rivers about 100 miles above Augusta, Ga. The tributaries have their sources in the Blue Ridge Mountains in North and South Carolina and Georgia, where more than one-fifth of the territory is in original oak forest. A large number of fine water powers occur on the tributaries and along the main river, the most noted being at Tallulah Falls, on Tallulah River, 335 feet in height, with a total fall of 525 feet in a distance of 2⅔ miles. In order to determine the value of these water powers, systematic measurements were begun at Calhoun Falls, S. C., on August 4, 1896.

This station is at the Seaboard Air Line Railway bridge across Savannah River, above the mouth of Beaverdam Creek and below Rocky River, and about 3 miles west of the town of Calhoun Falls, S. C. The river is here divided into two channels by a large island, containing several hundred acres. The east channel is a good section at ordinary stages, but at lowest water the current is very sluggish. The west channel, which is the main river, is obstructed by some very small islands and old cofferdams about the two piers; otherwise the section is fairly good. Peter Pfeiffer, a farmer, is the observer.

The chain gage is on the west channel, center span. The rod is nailed to the guard rail on the east side of the pulley, on the downstream side of the bridge. The center of the 2½-inch pulley is 193 feet from the initial point and is at a gage height of 55.26 feet. The zero point on the rod is 10 feet from the center of the pulley. The chain, from the bottom of the weight to the index, is 65.40 feet. One bench mark on the top of the iron stringer under the cross-ties near the gage is 54.0 feet above the datum of the gage. The other is on the top of the east end pier of the east channel, and is 29.87 feet above the zero of the gage.

This station is situated at the head of Trotters Shoal, the largest shoal on the main river. The observer is paid by the United States Weather Bureau.

The following discharge measurements were made during 1902:

July 19: Gage height, 2.50 feet; discharge, 2,517 second-feet.
October 1: Gage height, 3.45 feet; discharge, 6,844 second-feet.

Daily gage height, in feet, of Savannah River near Calhoun Falls, S. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.00	8.00	16.00	4.00	2.10	1.80	2.00	3.00	2.50	3.50	3.10	3.10
2	5.00	16.30	9.00	3.90	2.70	1.70	2.00	3.50	2.40	3.20	3.00	3.00
3	3.90	12.00	6.00	3.80	2.40	1.70	1.90	3.70	2.40	3.00	2.80	6.90
4	3.80	7.50	4.60	3.80	2.20	1.70	1.90	3.00	2.50	2.90	2.70	6.70
5	3.70	5.00	4.20	3.70	2.20	1.70	1.90	2.80	2.50	3.20	2.70	4.50
6	3.70	4.50	4.10	3.70	2.10	1.60	1.90	2.60	2.50	3.40	2.60	4.20
7	3.60	4.20	4.00	3.60	2.30	1.60	2.00	2.30	2.40	3.20	2.70	4.00
8	3.60	4.00	3.90	3.60	2.30	1.60	2.00	2.20	2.30	3.00	2.90	3.80
9	3.50	3.90	3.90	3.50	2.20	1.50	2.40	2.10	3.20	2.90	2.60	3.80
10	3.50	3.90	3.80	3.50	3.00	1.50	2.40	2.00	6.00	2.80	2.40	3.70
11	3.40	3.80	3.80	3.40	2.80	1.40	2.70	2.00	4.90	2.80	2.20	3.50
12	3.40	3.80	3.70	3.40	2.70	1.40	3.00	2.00	4.00	2.70	2.10	3.40
13	3.30	3.70	4.00	3.30	2.50	1.40	3.00	2.30	3.90	2.60	2.00	3.90
14	3.30	3.70	3.90	3.20	2.40	1.40	3.40	3.00	3.80	3.00	1.90	3.70
15	3.20	3.70	3.90	3.10	2.30	1.50	3.70	2.50	3.50	2.90	1.90	3.60
16	3.20	3.80	4.90	3.00	2.20	5.00	4.00	2.40	3.30	2.80	1.80	3.50
17	3.10	3.80	8.90	3.00	2.20	4.00	3.90	2.70	3.10	2.70	1.80	3.60
18	3.10	3.80	6.00	3.20	2.00	3.30	3.80	2.60	2.90	2.50	1.80	4.90
19	3.20	3.90	4.50	3.10	2.00	3.00	3.70	2.50	3.70	2.30	1.70	4.00
20	3.20	3.90	4.20	3.00	2.00	2.80	2.60	2.30	3.20	2.30	1.70	3.80
21	3.20	4.00	4.00	3.00	2.10	2.80	2.60	2.20	3.00	2.30	1.70	3.70
22	3.30	3.90	3.90	2.90	2.20	2.50	2.60	2.10	3.00	2.20	1.60	3.90
23	3.30	3.80	3.80	2.80	2.00	2.40	2.50	2.00	3.00	2.20	1.70	3.80
24	3.20	3.80	3.80	2.70	2.00	2.40	2.50	2.40	2.90	2.10	1.70	3.60
25	3.10	3.90	3.80	2.60	2.00	2.30	2.40	2.10	4.00	2.10	1.90	3.50
26	3.00	3.80	3.70	2.50	2.00	2.20	2.40	2.00	4.90	2.00	3.90	3.50
27	3.00	3.80	3.70	2.40	1.90	2.20	2.30	2.20	4.00	4.00	3.00	3.40
28	3.20	16.40	4.20	2.30	1.90	2.10	3.00	3.00	3.90	3.90	2.90	3.40
29	3.50	.....	9.30	2.20	1.90	2.00	3.00	3.10	3.50	3.70	2.70	3.50
30	4.00	.....	7.00	2.20	1.80	2.00	3.20	2.80	3.20	3.40	2.90	3.90
31	4.10	.....	5.50	.....	1.80	.....	3.40	2.60	.....	3.30	.....	3.70

Rating table for Savannah River near Calhoun Falls, S. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	1,175	3.4	5,640	5.4	14,340	9.5	32,175
1.6	1,350	3.6	6,510	5.6	15,210	10.0	34,350
1.8	1,545	3.8	7,380	5.8	16,080	11.0	38,700
2.0	1,760	4.0	8,250	6.0	16,950	12.0	43,050
2.2	1,990	4.2	9,120	6.5	19,125	13.0	47,400
2.4	2,280	4.4	9,990	7.0	21,300	14.0	51,750
2.6	2,690	4.6	10,860	7.5	23,475	15.0	56,100
2.8	3,150	4.8	11,735	8.0	25,650	16.0	60 450
3.0	3,900	5.0	12,600	8.5	27,825	17.0	64,800
3.2	4,770	5.2	13,470	9.0	30,000	18.0	69,150

Estimated monthly discharge of Savannah River near Calhoun Falls, S. C.

[Drainage area, 2,712 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	21,300	3,900	6,370	2.35	2.71
February	62,190	6,945	14,247	5.25	5.47
March	60,450	6,945	13,302	4.90	5.65
April	8,250	1,990	4,776	1.76	1.96
May	3,900	1,545	2,070	.76	.88
June	12,600	1,175	2,488	.92	1.03
July	8,250	1,650	3,541	1.31	1.51
August	6,945	1,760	2,790	1.03	1.19
September	16,950	2,120	5,651	2.08	2.32
October	8,250	1,760	3,818	1.41	1.63
November	7,815	1,350	2,556	.94	1.05
December	20,865	3,900	7,899	2.91	3.35
The year	62,190	1,175	5,792	2.12	28.75

BROAD RIVER (OF GEORGIA) NEAR CARLTON, GA.

Broad River rises in the northeastern part of Georgia and flows in a southeasterly direction, passing between Elbert and Wilkes counties, and emptying into Savannah River 8 miles below Calhoun Falls station. The drainage area is a rolling country largely covered with timber. Measurements were begun on Broad River at Carlton on May 27, 1897, this station being established by Max Hall. It is located on the bridge of the Seaboard Air Line Railway, 3 miles east of Carlton, Ga., and 2 miles above the mouth of South Fork. The iron bridge is 250 feet long and is approached at each side by wooden trestles. The initial point of sounding is the end of the iron bridge at the right bank, upstream. The length of the wire gage is 56.35 feet. The bench mark is the top of the upstream iron girder under the cross-ties at 30 feet from the initial point, and is 51 feet above datum. The zero of gage is 384.5 feet above sea level. The channel is straight and the flow uninterrupted except by one pier in the middle of the river. The banks are rather low and subject to overflow at high water. The bed is fairly constant. The observer, S. P. Power, jr., a farmer at Carlton, Ga., is paid by the United States Weather Bureau.

The following discharge measurements were made during 1902:

July 18: Gage height, 2.40 feet; discharge, 638 second-feet.
September 30: Gage height, 2.83 feet; discharge, 960 second-feet.

Daily gage height, in feet, of Broad River (of Georgia) near Carlton, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.70	7.50	23.20	4.30	3.30	2.90	2.20	2.30	2.30	3.90	2.30	4.30
2	4.00	23.20	9.50	4.00	3.40	2.80	2.20	2.20	2.20	3.60	2.20	3.60
3	3.70	17.10	5.80	3.80	3.30	2.70	2.30	3.10	2.20	2.70	2.20	6.60
4	3.50	6.30	4.80	3.80	3.30	2.70	2.80	3.00	2.20	2.60	2.10	6.40
5	3.40	5.70	4.40	3.70	3.20	2.60	2.60	2.70	2.20	3.60	2.20	4.50
6	3.30	4.10	4.20	3.70	3.70	2.60	2.30	2.50	2.20	3.00	2.50	4.00
7	3.20	3.80	3.90	3.70	3.30	2.60	2.20	2.30	2.10	2.60	2.50	3.30
8	3.10	3.50	3.80	3.60	3.20	2.80	2.40	2.20	2.10	2.40	2.30	3.00
9	3.10	3.40	4.00	3.50	3.20	2.60	2.80	2.10	3.30	2.40	2.30	2.90
10	3.00	3.40	3.90	3.40	3.10	2.50	2.40	2.10	4.70	2.30	2.30	2.70
11	3.00	3.30	3.80	3.40	3.10	2.50	2.40	2.10	3.60	2.50	2.30	2.70
12	2.90	3.30	3.70	3.30	3.10	2.50	2.70	2.60	2.60	3.50	2.30	2.60
13	2.90	3.30	4.60	3.30	3.00	2.50	2.60	2.30	2.80	2.90	2.20	2.80
14	2.90	3.20	4.30	3.30	3.40	2.50	2.40	5.00	2.80	2.70	2.20	2.80
15	2.90	3.30	4.40	3.30	3.10	2.70	4.80	4.80	2.60	2.80	2.20	2.80
16	2.90	3.50	5.10	3.80	3.00	3.30	3.40	3.00	2.50	2.50	2.20	2.90
17	2.80	3.60	8.50	4.00	3.00	2.80	2.60	3.50	2.30	2.50	2.20	4.30
18	2.80	3.50	6.00	4.60	3.00	2.60	2.40	3.00	2.30	2.40	2.90	3.60
19	2.90	3.40	4.20	3.60	3.00	2.60	2.30	2.40	2.80	2.30	2.90	3.10
20	3.00	3.50	3.90	3.60	3.00	3.00	2.30	2.90	2.40	2.30	2.50	2.90
21	3.00	3.60	3.70	3.50	3.10	2.70	2.30	2.90	2.50	2.30	2.40	2.80
22	3.10	4.00	3.70	3.40	3.00	2.60	2.30	2.30	2.30	2.20	2.40	3.80
23	2.90	3.60	3.60	3.30	3.00	2.50	2.20	2.50	2.20	2.30	2.40	3.40
24	2.80	3.50	3.60	3.30	2.90	2.40	2.20	2.40	2.20	2.30	2.30	3.10
25	2.90	4.40	3.50	3.30	2.90	2.40	2.30	2.30	5.90	2.20	2.30	3.00
26	2.80	4.60	3.50	3.20	2.80	2.40	2.30	2.30	8.20	2.20	4.60	2.80
27	2.80	3.90	3.50	3.20	2.80	2.40	2.20	2.20	4.60	2.30	4.00	2.80
28	3.00	24.50	3.90	3.10	2.70	2.40	3.10	2.40	3.40	2.50	3.90	2.60
29	4.40	.....	15.00	3.10	2.70	2.30	3.30	3.60	3.60	2.30	3.00	2.60
30	3.90	.....	12.00	3.20	2.60	2.30	2.30	3.10	3.30	2.30	2.60	3.30
31	4.10	.....	6.50	.....	2.60	.....	2.30	2.50	.....	2.30	.....	3.30

Rating table for Broad River (of Georgia) near Carlton, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	490	4.6	2,550	7.0	5,550	11.5	11,575
2.4	640	4.8	2,750	7.2	5,770	12.0	12,250
2.6	790	5.0	2,950	7.4	6,040	12.5	12,925
2.8	950	5.2	3,160	7.6	6,310	13.0	13,600
3.0	1,110	5.4	3,390	7.8	6,580	13.5	14,275
3.2	1,280	5.6	3,640	8.0	6,850	14.0	14,950
3.4	1,450	5.8	3,900	8.5	7,525	14.5	15,625
3.6	1,620	6.0	4,160	9.0	8,200	15.0	16,300
3.8	1,800	6.2	4,420	9.5	8,875	15.5	16,975
4.0	1,980	6.4	4,690	10.0	9,550	16.0	17,650
4.2	2,165	6.6	4,960	10.5	10,225	17.0	19,000
4.4	2,355	6.8	5,230	11.0	10,900		

Estimated monthly discharge of Broad River (of Georgia) near Carlton, Ga.

[Drainage area, 762 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
January	2,650	950	1,304	1.71	1.97
February	29,125	1,280	4,514	5.92	6.16
March	27,370	1,535	4,225	5.54	6.39
April	2,550	1,195	1,579	2.07	2.31
May	1,710	790	1,163	1.53	1.76
June	1,365	565	800	1.05	1.17
July	2,750	490	764	1.00	1.15
August	2,950	420	919	1.21	1.39
September	7,120	420	1,227	1.61	1.80
October	1,890	490	837	1.10	1.27
November	2,550	420	777	1.02	1.14
December	4,960	790	1,479	1.94	2.24
The year	29,125	420	1,632	2.14	28.75

MISCELLANEOUS MEASUREMENTS IN SAVANNAH RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in the Savannah drainage basin during 1902 by B. M. Hall and his assistants:

Miscellaneous discharge measurements in Savannah drainage basin.

Date.	Stream.	Locality.	Discharge.
July 18	Rocky River	Swearingen Mill, near Calhoun Falls, S. C.	128
July 19	Beaverdam Creek	Near Calhoun Falls, S. C	54
July 24	Toccoa Creek	Toccoa Falls, Ga	6
July 28	Brier Creek	Near Waynesboro, Ga	469
Aug. 7	Beaverdam Creek	Elberton, Ga	40
Nov. 10	do	do	53
Dec. 12	Brier Creek	Near Waynesboro, Ga	604

MISCELLANEOUS MEASUREMENTS IN OGEECHEE RIVER DRAINAGE BASIN.

The following miscellaneous measurements were made in the Ogeechee basin in 1902 by B. M. Hall and his assistants:

Miscellaneous discharge measurements in Ogeechee drainage basin.

Date.	Stream.	Locality.	Discharge.
July 24	Williamsons Swamp Creek.	Wadley, Ga	134
July 25	Ogeechee River	Near Louisville, Ga., above mouth of Rocky Comfort Creek.	199
July 25	Big Creek	Near Louisville, Ga	78
July 25	Ogeechee River	Near Louisville, Ga., below mouth of Rocky Comfort Creek.	603
July 26	do	Millen, Ga	1,097
July 26	Buckhead Creek	Millen, Ga., just above mouth	109
Dec. 10	Williamsons Swamp Creek.	Wadley, Ga	283
Dec. 10	Ogeechee River	6 miles from Wadley, Ga	2,134
Dec. 11	Buckhead Creek	Millen, Ga	701

ALTAMAHA RIVER DRAINAGE BASIN.

The Altamaha River is formed by the junction of Oconee and Ocmulgee rivers, which unite at the southern boundary of Montgomery County, Ga., about 100 miles from the coast. It flows in a southeasterly direction and empties into the Atlantic Ocean near Darien, Ga. Oconee River drains the eastern central part of Georgia. Its principal tributary is Apalachee River, which enters it in the southeastern part of Morgan County, Ga. Ocmulgee River, which is formed by the junction of Yellow and South rivers, in the northwestern part of Jasper County, Ga., drains the western central portion of the State.

During 1902 the United States Geological Survey maintained the following stations in this basin under the direction of B. M. Hall:

On the Oconee; at Barnett Shoals, at Dublin, and near Athens.

On the Apalachee; near Buckhead.

On the Ocmulgee; at Macon and near Flovilla.

On the Alcovy; near Covington.

OCONEE RIVER AT DUBLIN, GA.

Oconee River rises in the northern part of Georgia, near Gainesville, on the southern slope of the Chattahoochee Ridge, which separates the headwaters of this stream from the tributaries of the Chattahoochee River. It flows in a southeasterly direction and joins the Ocmulgee at the southern border of Montgomery County to form the Altamaha. The drainage area is for the most part hilly, and is made up of cultivated ground broken by extensive tracts of forest.

A station was established by the United States Weather Bureau in 1894 at Dublin, Ga., about 60 miles above the junction of the Oconee with the Ocmulgee, 45 miles below Milledgeville and 85 miles below the old Cary station. The station was discontinued on April 30, 1897, but was reestablished by the Georgia geological survey February 11, 1898. Since October 15, 1898, the station has been maintained by the United States Weather Bureau. The station is located in the eastern part of Dublin, Ga. The gage is a vertical rod fastened to the lower side of the middle pier of the Wrightsville and Tennille Railroad bridge. The channel is straight and without obstructions, except the bridge piers. The current is swift. The banks are high and not subject to overflow. Discharge measurements are made from the upper side of the iron highway bridge, which is about 100 yards above the railroad bridge at which the gage is located. The initial point for soundings is the end of the bridge on the right bank of the river. The observer, J. W. Scarborough, is paid by the United States Weather Bureau.

The following discharge measurements were made during 1902:

November 12: Gage height, 0.27 feet; discharge, 1,651 second-feet.
November 12: Gage height, 0.25 feet; discharge, 1,615 second-feet.
November 13: Gage height, 0.27 feet; discharge, 1,619 second-feet.

Daily gage height, in feet, of Oconee River at Dublin, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	10.00	4.00	11.00	15.30	3.40	1.00	0.20	0.00	0.70	2.80	0.80	4.00
2	12.00	6.30	13.40	17.60	3.30	1.00	−.10	1.70	.50	1.70	.50	5.30
3	14.10	8.00	23.00	17.50	4.50	1.20	−.20	.80	.30	2.00	.20	6.10
4	14.90	9.50	25.50	17.10	5.50	1.80	−.20	.30	−.10	2.50	−.10	7.50
5	15.30	14.00	25.80	16.00	4.70	1.60	−.20	2.90	−.40	1.60	−.20	8.00
6	14.60	19.00	24.50	14.10	3.80	.90	1.40	4.30	−.60	2.90	−.20	8.70
7	12.40	20.00	22.00	11.30	3.50	.70	.90	4.40	−.90	2.70	.30	9.00
8	7.00	19.50	19.00	9.00	3.00	.60	.70	3.50	−1.10	2.40	.60	9.80
9	4.40	18.00	16.00	9.00	3.10	2.00	.20	2.00	−1.20	1.80	.80	9.00
10	3.90	15.60	13.00	9.00	2.70	3.90	−.20	.90	−1.20	1.00	.60	5.80
11	3.60	12.30	9.00	9.00	2.70	4.00	−.70	.50	−1.30	.70	.50	3.50
12	3.20	7.30	7.50	8.50	2.70	3.00	1.00	1.00	1.20	.80	.40	3.20
13	3.00	5.00	6.50	7.00	2.50	1.30	2.50	2.40	2.00	.90	.30	3.00
14	2.80	4.30	6.00	6.00	2.30	1.00	4.50	1.30	1.50	1.00	.20	4.80
15	2.60	4.10	7.10	5.60	2.00	1.00	3.50	.70	.70	1.20	.10	4.90
16	2.50	4.10	9.80	5.50	2.20	1.20	4.40	1.00	.40	2.00	.00	3.80
17	2.40	4.80	12.70	5.50	3.00	4.50	5.10	2.30	.80	1.00	−.10	3.00
18	2.40	5.00	14.20	6.00	3.00	4.50	5.50	3.00	.60	.80	−.10	2.60
19	2.40	5.00	19.00	7.90	2.70	2.50	3.30	1.70	.20	.50	−.10	3.50
20	2.40	4.80	21.00	9.00	3.00	3.70	1.20	.80	−.20	.10	1.00	3.00
21	2.50	4.60	19.70	10.00	2.90	2.80	.80	.40	.30	−.20	2.00	2.00
22	3.10	4.50	18.00	10.00	2.80	2.00	.40	.10	.80	−.40	1.40	1.40
23	3.70	6.50	15.90	8.10	2.70	2.00	2.40	.50	.70	−.50	1.00	4.00
24	3.70	6.60	13.70	6.00	2.60	1.50	1.00	.20	.50	−.50	.70	5.50
25	3.40	7.00	11.60	5.00	2.30	1.10	.50	−.20	.20	−.60	.50	5.00
26	3.00	8.00	10.10	4.60	2.00	.70	1.70	−.40	−.10	−.60	1.00	2.50
27	2.90	8.60	9.50	4.30	1.70	.50	1.00	−.40	1.00	−.30	4.40	2.00
28	2.80	9.60	9.10	3.90	1.50	.40	1.20	−.30	3.50	1.50	5.50	1.70
29	2.60	.....	8.90	3.60	1.40	.30	2.00	.10	4.00	2.00	4.50	1.50
30	2.60	.....	10.90	3.60	1.30	.20	1.80	.20	4.20	1.80	3.50	1.30
31	3.00	.....	12.10	.....	1.10	.....	1.30	.50	.....	1.50	.....	1.00

Rating table for Oconee River at Dublin, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	935	2.2	2,940	5.6	6,244	10.5	11,830
1.0	1,010	2.4	3,090	5.8	6,472	11.0	12,400
.8	1,090	2.6	3,250	6.0	6,700	11.5	12,970
.6	1,180	2.8	3,410	6.2	6,928	12.0	13,540
.4	1,270	3.0	3,570	6.4	7,156	13.0	14,680
.2	1,370	3.2	3,740	6.6	7,384	14.0	15,820
.0	1,475	3.4	3,910	6.8	7,612	15.0	16,960
.2	1,585	3.6	4,090	7.0	7,840	16.0	18,100
.4	1,700	3.8	4,280	7.2	8,068	17.0	19,240
.6	1,820	4.0	4,480	7.4	8,296	18.0	20,380
.8	1,945	4.2	4,690	7.6	8,524	19.0	21,520
1.0	2,075	4.4	4,900	7.8	8,752	20.0	22,660
1.2	2,210	4.6	5,120	8.0	8,980	21.0	23,800
1.4	2,350	4.8	5,340	8.5	9,550	22.0	24,940
1.6	2,490	5.0	5,560	9.0	10,120	23.0	26,080
1.8	2,640	5.2	5,788	9.5	10,690	24.0	27,220
2.0	2,790	5.4	6,016	10.0	11,260	25.0	28,360

Estimated monthly discharge of Oconee River at Dublin, Ga.

[Drainage area, 4,182 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	17,302	3,090	6,315	1.51	1.74
February	22,660	4,480	9,813	2.35	2.45
March	29,272	6,700	16,243	3.88	4.47
April	19,924	4,090	9,942	2.38	2.66
May	6,130	2,140	3,436	.82	.95
June	5,010	1,585	2,685	.64	.71
July	6,130	1,135	2,567	.61	.70
August	4,900	1,270	2,318	.54	.62
September	4,690	900	1,904	.46	.51
October	3,490	1,180	2,203	.53	.61
November	6,130	1,370	2,189	.52	.58
December	11,032	2,075	5,134	1.23	1.42
The year	29,272	900	5,409	1.29	17.48

OCONEE RIVER AT BARNETT SHOALS, GA.

This station was established by Prof. C. M. Strahan, of the University of Georgia, on August 6, 1901. It is located at Barnett's bridge, 1 mile above Barnett Shoals and 4 miles east of Watkinsville, Ga.

The gage is a 10-foot rod, graduated to feet and tenths, nailed to a tree on the left bank just above the bridge. The gage is extended to a length of 16 feet by means of a plank marked in feet fastened above the rod. The bench mark is a large nail driven into the tree, and its elevation is 6 feet above the datum of the gage.

Discharge measurements were made from the downstream side of the bridge, which is a covered, lattice, single-span bridge, with a total length of 109 feet between abutments. The observer was R. L. McRee, a storekeeper at Barnett Shoals, who read the gage once daily at ordinary stages and twice daily during low stages, when the regularity of the flow is affected by the small dam of the Georgia factory, 6½ miles upstream.

The station was discontinued on August 23, 1902, for want of an observer.

The following discharge measurements were made during 1902:

January 1: Gage height, 6.35 feet; discharge, 5,061 second-feet.
March 22: Gage height, 3.20 feet; discharge, 1,412 second-feet.
May 31: Gage height, 2.10 feet; discharge, 800 second-feet.
June 28: Gage height, 1.77 feet; discharge, 619 second-feet.

Daily gage height, in feet, of Oconee River at Barnett Shoals, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1902.								
1	5.80	8.00	14.00	.....	.....	2.20	1.50	1.60
2	4.00	14.00	8.00	.....	.....	2.10	1.50	1.60
3	3.00	10.00	6.00	.....	.....	2.10	1.50	2.40
4	2.90	8.90	5.00	.....	.....	2.10	2.60	2.40
5	2.80	7.60	4.50	.....	.....	2.00	2.70	3.90
6	2.70	6.00	4.00	.....	.....	2.00	1.80	2.50
7	2.60	4.80	3.60	.....	.....	2.20	1.80	1.90
8	2.50	3.90	[a] 3.00	.....	.....	3.00	1.90	1.70
9	2.40	3.30	.....	.....	.....	2.30	1.70	1.60
10	2.40	3.00	.....	.....	.....	2.20	1.90	1.60
11	2.40	2.80	.....	.....	.....	2.10	2.50	1.80
12	2.40	2.70	.....	.....	.....	2.10	2.40	2.40
13	2.40	2.70	.....	.....	.....	1.90	3.20	1.80
14	2.30	2.70	.....	.....	.....	1.80	2.20	1.60
15	2.30	3.00	.....	.....	.....	1.90	4.30	1.80
16	2.30	3.30	.....	.....	.....	2.50	4.30	1.60
17	2.30	3.30	.....	.....	.....	2.20	2.50	1.70
18	2.30	3.20	.....	.....	.....	2.10	2.00	1.70
19	2.40	3.00	.....	.....	.....	2.00	1.90	1.50
20	2.30	2.80	.....	.....	2.20	2.70	1.80	1.70
21	2.50	2.60	.....	.....	2.20	2.00	1.70	1.80

[a] No observer obtainable. Discontinued.

Daily gage height, in feet, of Oconee River at Barnett Shoals, Ga.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1902.								
22	2.40	2.60	.....	.....	2.20	1.80	1.70	1.90
23	2.30	2.50	.....	.....	2.20	1.80	1.60	[a] 1.60
24	2.60	2.50	.....	.....	2.30	1.70	1.60	.....
25	2.50	2.50	.....	.....	2.30	1.70	1.60	.....
26	2.40	2.50	.....	.....	2.30	1.70	1.80	.....
27	2.50	8.00	.....	.....	2.20	1.70	1.70	.....
28	2.60	17.00	.....	.....	2.10	1.60	1.70	.....
29	2.90	.....	.....	.....	2.10	1.70	2.00	.....
30	3.60	.....	.....	.....	2.00	1.70	1.80	.....
31	4.00	.....	.....	.....	2.00	.....	1.70	.....

[a] No observer obtainable. Discontinued.

Rating table for Oconee River at Barnett Shoals, Georgia, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	568	4.6	2,615	7.6	7,522	10.6	13,582
1.8	665	4.8	2,827	7.8	7,926	10.8	13,986
2.0	763	5.0	3,055	8.0	8,330	11.0	14,390
2.2	864	5.2	3,299	8.2	8,734	11.2	14,794
2.4	967	5.4	3,559	8.4	9,138	11.4	15,198
2.6	1,074	5.6	3,835	8.6	9,542	11.6	15,602
2.8	1,188	5.8	4,130	8.8	9,946	11.8	16,006
3.0	1,310	6.0	4,445	9.0	10,350	12.0	16,410
3.2	1,440	6.2	4,780	9.2	10,754	12.5	17,420
3.4	1,578	6.4	5,135	9.4	11,158	13.0	18,430
3.6	1,724	6.6	5,510	9.6	11,562	13.5	19,440
3.8	1,878	6.8	5,906	9.8	11,966	14.0	20,450
4.0	2,060	7.0	6,310	10.0	12,370	15.0	22,470
4.2	2,233	7.2	6,714	10.2	12,774	16.0	24,490
4.4	2,418	7.4	7,118	10.4	13,178	17.0	26,510

Estimated monthly discharge of Oconee River at Barnett Shoals, Georgia.

[Drainage area, 835 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	4,130	915	1,211	1.45	1.67
February	26,510	1,020	4,456	5.34	5.56
March 1 to 8			5,486	6.57	1.95
May 20 to 31			851	1.02	0.46
June	1,310	568	748	0.90	1.00
July	2,324	520	842	1.01	1.16
August 1 to 23			736	0.88	0.75

MIDDLE OCONEE RIVER NEAR ATHENS, GA.

Middle Oconee River rises in Hall County and flows southeastward through Jackson and Clarke counties to its junction with the east fork, 6 miles below Athens. It drains a rolling area of 300 square miles.

Measurements were begun at Athens on October 11, 1901, the station having been established by Prof. C. M. Strahan, of the University of Georgia. It is located on a wagon bridge, known as Mitchell's Bridge, on the Athens and Lawrenceville road, 3½ miles from Athens and about 7½ miles above the junction of Middle Oconee with its eastern fork. It is 4 miles above the dam of the Princeton factory, an 8-foot shoal intervening, and one-third of a mile below the dam of the Athens Electric Railway Company. The gage is of wire, mounted on the north truss, near the east end of the bridge. It is protected by a plank cover and locked. The bridge is of the covered wooden lattice type. The bench mark is the top of the lower chord at the gage pulley, 26.85 feet above the river bottom, which is the zero point of the gage, the latter being set to read zero when the weight touches the bottom. The graduations are laid off on the lower chord to 20 feet, and can be extended to 26 feet. The initial point for soundings is a spike at the west end of the north bridge truss. The channel is straight and unobstructed except by remains of old piers just inside the present piers, the old piers being covered at a gage height of 3 feet. The banks are high and the approaches short. The water rises rapidly in time of flood, the maximum gage height being 22.9 feet and the average gage height 2.5 to 3 feet. The station was discontinued on October 25, 1902, for want of an observer.

The following discharge measurements were made during 1902 by C. M. Strahan:

Discharge measurements of Middle Oconee River near Athens, Ga.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 3	C. M. Strahan	3.65	855
February 28	do	22.50	16,971
May 2	do	([a])	836
June 30	do	1.70	275
July 17	do	2.10	400
July 19	do	1.95	350
July 22	do	1.85	318

[a] Gaging made 7 miles above Athens.

Daily gage height, in feet, of Middle Oconee River near Athens, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.										
1	4.20	6.20	19.00	3.00	2.50	2.10	1.70	1.80	1.70	2.20
2	3.90	14.00	7.30	3.20	2.50	2.10	1.70	1.80	1.70	2.30
3	3.70	17.00	5.70	3.00	2.50	2.10	2.10	2.90	1.70	2.40
4	3.50	5.50	5.20	2.90	2.40	2.00	2.00	2.00	1.70	1.90
5	3.50	4.20	4.80	2.90	2.40	2.00	1.90	2.70	1.70	2.30
6	3.50	3.90	4.60	2.90	2.40	2.00	1.80	2.00	1.70	2.30
7	3.40	3.80	4.40	2.90	2.40	2.40	1.80	2.00	1.60	2.10
8	3.40	3.80	3.80	3.00	2.40	2.30	1.80	1.90	1.60	1.90
9	3.30	3.60	3.60	3.00	2.30	2.20	1.80	1.80	2.10	1.80
10	3.30	3.50	3.60	2.90	2.30	2.10	1.80	1.80	2.10	1.80
11	3.30	3.50	3.30	2.90	2.30	2.10	1.90	1.70	1.90	1.80
12	3.20	3.40	3.30	2.80	2.30	2.00	2.00	2.10	1.80	2.30
13	3.20	3.40	4.00	2.80	2.30	2.00	2.50	2.00	2.50	2.30
14	3.20	3.40	3.50	2.80	2.30	2.00	3.80	1.90	2.30	2.10
15	3.20	3.60	3.40	2.80	2.30	2.20	2.30	1.80	1.90	2.00
16	3.20	3.70	5.30	2.80	2.20	2.40	2.20	1.70	1.60	1.90
17	3.20	3.60	8.40	3.20	2.20	2.20	2.10	1.70	1.60	1.90
18	3.10	3.50	4.70	3.70	2.20	2.10	2.00	1.70	1.60	1.80
19	3.20	3.50	3.60	3.00	2.20	2.10	1.90	1.70	1.80	1.80
20	3.30	3.60	3.30	2.80	2.20	2.00	1.80	1.70	2.10	1.80
21	3.30	3.70	3.10	2.80	2.20	2.00	1.80	1.70	1.90	1.80
22	3.20	3.70	3.00	2.80	2.20	2.00	1.90	1.70	1.70	1.80
23	3.20	3.50	2.90	2.70	2.20	2.00	1.90	1.60	1.70	1.80
24	3.20	3.50	2.90	2.70	2.20	1.90	1.90	1.60	1.60	1.80
25	3.20	4.00	2.90	2.60	2.20	1.90	2.20	1.60	3.60	[a] 1.80
26	3.20	4.30	2.90	2.60	2.20	1.80	1.80	1.60	5.60	.....
27	3.20	3.80	2.90	2.60	2.20	1.80	2.00	1.60	3.90	.....
28	3.40	25.50	3.40	2.50	2.10	1.80	2.30	1.60	3.00	.....
29	4.40	.....	11.30	2.50	2.10	1.80	2.00	1.70	2.10	.....
30	3.90	.....	18.60	2.60	2.10	1.70	1.80	1.70	2.00	.....
31	4.30	.....	4.60	.....	2.10	.....	1.80	1.70	.....	.....

[a] Discontinued. No observer obtainable.

Rating table for Middle Oconee River near Athens, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	243	5.6	1,915	9.6	5,340	16.0	11,100
1.8	307	5.8	2,050	9.8	5,520	16.5	11,550
2.0	371	6.0	2,190	10.0	5,700	17.0	12,000
2.2	435	6.2	2,336	10.2	5,880	17.5	12,450
2.4	499	6.4	2,490	10.4	6,060	18.0	12,900
2.6	563	6.6	2,652	10.6	6,240	18.5	13,350
2.8	627	6.8	2,822	10.8	6,420	19.0	13,800
3.0	691	7.0	3,000	11.0	6,600	19.5	14,250
3.2	755	7.2	3,180	11.2	6,780	20.0	14,700
3.4	819	7.4	3,360	11.4	6,960	20.5	15,150
3.6	884	7.6	3,540	11.6	7,140	21.0	15,600
3.8	966	7.8	3,720	11.8	7,320	21.5	16,050
4.0	1,046	8.0	3,900	12.0	7,500	22.0	16,500
4.2	1,131	8.2	4,080	12.5	7,950	22.5	16,950
4.4	1,217	8.4	4,260	13.0	8,400	23.0	17,400
4.6	1,315	8.6	4,440	13.5	8,850	23.5	17,850
4.8	1,426	8.8	4,620	14.0	9,300	24.0	18,300
5.0	1,541	9.0	4,800	14.5	9,750	24.5	18,750
5.2	1,661	9.2	4,980	15.0	10,200	25.0	19,200
5.4	1,786	9.4	5,160	15.5	10,650		

Estimated monthly discharge of Middle Oconee River near Athens, Ga.

[Drainage area, 395 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	1,217	723	837	2.12	2.44
February	19,560	819	2,362	5.98	6.23
March	13,800	659	2,189	5.54	6.39
April	884	531	652	1.65	1.84
May	531	403	458	1.16	1.34
June	499	275	383	.97	1.08
July	966	275	375	.95	1.10
August	659	243	317	.80	.92
September	1,915	243	426	1.08	1.20
October 1-25			367	.93	.87

NOTE.—Discontinued. No observer obtainable.

APALACHEE RIVER NEAR BUCKHEAD, GA.

A gage was established at this station on February 13, 1901, and observations were commenced on March 1. It is located at the iron wagon bridge over Apalachee River, 3½ miles north of the town of Buckhead, Ga. The bridge is a single iron span 103 feet long, supported by four tubular iron piers. Its floor is about 25 feet above low water. The left bank is high and will overflow to a distance of about 75 feet only beyond ordinary high-water mark. The right bank is liable to overflow to a distance of about 400 feet, commencing at a gage height of 6 feet. The overflow areas on both banks are crossed by wooden trestle approaches. The trestle on the right bank is subject to overflow at a gage height of 18 feet, rendering it impossible to make discharge measurements of high floods. The section is good, but the current is irregular on account of the ruins of old bridge piers in the river about 50 feet above. The general course of the river both above and below the station is slightly curved.

The gage is graduated to feet and tenths, with brass figures and staples, and consists of two parts. The first section, extending from 0 to 10 feet, is fastened to a small ash tree on the left bank, about 100 feet below the bridge. The second section, extending from 6 to 20 feet, is nailed to the upstream post of the last wooden bent next to the iron bridge on the right bank.

Bench mark No. 1 is the top of the iron pier on the right bank, downstream side. Its elevation is 25 feet above the datum of the gage.

Bench mark No. 2 is the top of the second iron crossbeam from the left bank on the downstream side. Its elevation is 25.72 feet above the datum of the gage.

The observer is A. S. Adams, a farmer living one-third of a mile from the bridge. The observer is paid by the Georgia geological survey.

The following discharge measurements were made during 1902:

February 8, gage height, 3.95 feet; discharge, 821 second-feet.
June 7, gage height, 1.52 feet; discharge, 262 second-feet.
July 19, gage height, 1.50 feet; discharge, 253 second-feet.

Daily gage height, in feet, of Apalachee River near Buckhead, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	11.00	6.20	25.00	8.00	2.60	1.75	1.60	1.80	1.60	2.50	1.50	2.80
2	7.00	17.50	20.00	5.50	2.80	1.75	1.60	1.60	1.50	2.00	1.50	3.10
3	5.50	20.00	15.00	4.50	2.70	1.75	2.10	4.00	1.50	1.90	1.50	3.50
4	4.50	15.00	10.00	4.00	2.70	1.70	2.00	4.50	1.50	1.80	1.60	5.00
5	4.20	11.00	7.00	3.80	2.60	1.70	1.80	4.00	1.40	1.80	1.60	4.50
6	4.10	8.00	6.00	3.70	2.60	1.70	1.70	3.00	1.40	1.80	1.60	3.50
7	4.00	6.00	5.00	4.50	2.50	1.70	1.60	2.70	1.60	1.80	1.50	3.20
8	3.80	4.00	4.00	4.00	2.40	4.00	1.55	2.50	1.80	1.70	1.50	3.10
9	3.70	3.90	3.50	3.80	2.40	5.50	1.50	2.20	1.70	1.70	1.50	3.00
10	3.50	3.80	3.50	3.60	2.30	4.00	1.50	2.00	1.70	1.70	1.50	3.00
11	3.40	3.80	3.30	3.50	2.30	3.00	1.60	1.90	1.90	1.70	1.45	2.80
12	3.20	3.80	3.30	3.50	2.30	2.70	2.00	1.85	2.00	1.70	1.45	2.50
13	3.10	3.70	3.80	3.50	2.30	2.40	1.90	1.80	2.50	1.70	1.45	2.20
14	3.00	3.70	4.50	3.40	2.40	2.10	6.00	1.75	4.00	1.70	1.45	2.10
15	2.90	3.70	5.00	3.40	2.40	2.00	3.00	1.70	3.80	1.70	1.40	3.00
16	2.90	3.70	6.50	3.30	2.40	4.50	2.50	1.70	3.40	1.60	1.40	3.50
17	2.80	3.80	10.00	3.30	2.30	3.80	2.30	1.60	3.00	1.60	1.50	3.20
18	2.80	3.90	7.50	4.50	2.30	2.80	2.10	1.60	2.80	1.60	1.70	3.00
19	2.80	3.90	6.00	4.30	2.30	2.50	2.00	1.50	2.80	1.60	1.60	2.80
20	2.80	3.80	5.50	4.00	2.20	2.20	1.90	1.50	3.20	1.60	1.60	2.70
21	2.70	3.70	5.20	3.80	2.20	2.00	1.80	1.50	3.00	1.55	1.60	2.60
22	2.70	3.70	5.00	3.60	2.10	1.90	1.75	1.40	2.80	1.55	1.60	3.60
23	2.60	3.80	4.80	3.40	2.10	1.90	1.70	1.40	2.70	1.50	1.60	3.00
24	2.60	3.90	4.70	3.20	2.00	1.80	1.65	1.20	2.70	1.50	2.00	2.90
25	2.80	4.00	4.50	3.00	1.90	1.80	1.60	1.10	3.00	1.50	2.10	2.70
26	3.00	5.00	4.30	2.70	1.90	1.75	1.50	1.00	3.00	1.50	2.00	2.60
27	3.20	16.00	3.80	2.80	1.85	1.70	1.60	1.20	2.80	1.80	2.00	2.60
28	3.60	20.00	4.40	2.70	1.80	1.70	2.10	1.30	2.80	1.80	1.90	2.50
29	3.70	.....	4.50	2.70	1.80	1.65	2.60	1.50	2.70	1.70	2.10	2.50
30	4.00	.....	7.00	2.70	1.75	1.65	2.10	1.60	3.50	1.70	2.60	3.20
31	4.50	.....	12.00	.....	1.75	.....	1.90	1.60	.....	1.60	.....	3.00

Rating table for Apalachee River near Buckhead, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	205	5.0	1,185	10.5	2,697	20.5	5,448
1.2	219	5.2	1,240	11.0	2,835	21.0	5,585
1.4	241	5.4	1,295	11.5	2,972	21.5	5,722
1.6	271	5.6	1,350	12.0	3,110	22.0	5,860
1.8	310	5.8	1,405	12.5	3,247	22.5	5,998
2.0	360	6.0	1,460	13.0	3,385	23.0	6,135
2.2	415	6.2	1,515	13.5	3,522	23.5	6,272
2.4	470	6.4	1,570	14.0	3,660	24.0	6,410
2.6	525	6.6	1,625	14.5	3,798	24.5	6,548
2.8	580	6.8	1,680	15.0	3,935	25.0	6,685
3.0	635	7.0	1,735	15.5	4,072	25.5	6,822
3.2	690	7.2	1,790	16.0	4,210	26.0	6,960
3.4	745	7.4	1,845	16.5	4,348	26.5	7,098
3.6	800	7.6	1,900	17.0	4.485	27.0	7,235
3.8	855	7.8	1,955	17.5	4,622	27.5	7,342
4.0	910	8.0	2,010	18.0	4,760	28.0	7,510
4.2	965	8.5	2,147	18.5	4,898	28.5	7,648
4.4	1,020	9.0	2,285	19.0	5,035	29.0	7,785
4.6	1,075	9.5	2,422	19.5	5,172		
4.8	1,130	10.0	2,560	20.0	5,310		

Estimated monthly discharge of Apalachee River near Buckhead, Ga.

[Drainage area, 440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	2,835	525	842	1.91	2.20
February	5,310	827	1,708	3.88	4.04
March	6,685	717	1,714	3.90	4.50
April	2,010	552	843	1.92	2.14
May	580	300	448	1.02	1.18
June	1,322	280	469	1.07	1.19
July	1,460	255	375	.85	.98
August	1,047	205	368	.84	.97
September	910	241	495	1.12	1.25
October	497	255	294	.67	.77
November	525	241	298	.68	.76
December	1,185	388	641	1.46	1.68
The year	6,685	205	708	1.61	21.66

OCMULGEE RIVER AT MACON, GA.

The Ocmulgee River rises in the north-central part of Georgia and flows in a southeasterly direction, joining the Oconee south of Mount Vernon to form the Altamaha River. The drainage area has the same general features as that of the Oconee. A station was established by the United States Weather Bureau on January 21, 1893, and measurements were begun by the United States Geological Survey in 1895. The wire gage on the Macon, Dublin and Savannah Railroad bridge having been twice stolen in the spring of 1897, the observations were taken on the Weather Bureau gage, which is a vertical rod bolted to the stone pier of the Central Railroad bridge. It is referred to the same datum. The bench mark is the top of the track on the Central Railroad bridge. It is 54.85 feet above the zero of the gage. (See United States Weather Bureau reports for description of other bench marks.) Measurements of discharge are made from the wagon bridge a short distance above. The channel is straight and without obstructions, except two bridge piers. The banks are high and not subject to overflow. The bed of the river is soft and changeable. W. T. Bass, a clerk in a store near the gage, was observer for the United States Geological Survey and the Georgia geological survey until June 1, 1899. Then the station was resumed by the United States Weather Bureau, in charge of T. S. Collins, until March, 1901; since that time the Weather Bureau official at that point has been John R. Weeks.

Discharge measurements of Ocmulgee River at Macon, Ga.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
June 26	Max Hall	3.53	1,074
July 25	W. E. Hall	3.50	689
July 31	H. G. Stokes	4.20	1,126
September 15	W. E. Hall	3.61	885
September 18	do	3.30	705
October 23	A. T. Mitchelson	3.10	829
November 13	do	3.10	779
November 26	do	9.29	6,483
Do	do	9.59	5,900
December 5	do	9.00	4,612

Daily gage height, in feet, of Ocmulgee River at Macon, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	15.70	11.50	22.80	12.80	5.80	4.20	3.30	3.90	4.00	5.00	3.50	8.70
2	11.00	18.00	20.90	10.40	5.70	4.10	3.20	3.80	3.60	5.60	3.30	7.30
3	8.10	19.20	17.30	8.80	5.70	4.50	3.30	3.70	3.50	4.50	3.30	13.30
4	6.30	18.50	13.00	8.50	5.80	4.30	3.10	5.50	3.30	3.90	3.20	11.90
5	5.20	15.00	11.10	8.20	5.50	4.10	3.30	5.90	3.40	4.30	3.20	9.50
6	4.70	10.60	10.10	7.90	5.40	4.00	3.30	9.50	3.40	5.20	3.30	7.00
7	4.40	8.40	9.40	7.60	5.30	4.00	3.30	5.50	3.40	4.80	3.40	5.90
8	4.20	7.20	8.70	10.50	5.20	6.20	3.20	4.60	3.30	4.20	3.70	5.20
9	4.00	6.40	8.40	10.20	5.20	6.10	3.30	4.00	3.40	3.80	3.50	4.70
10	3.90	5.80	8.20	9.80	5.50	5.00	3.20	3.80	3.40	3.70	3.40	4.20
11	3.70	5.50	7.90	7.70	5.50	4.60	3.20	3.70	3.80	3.50	3.30	3.80
12	3.60	5.30	7.70	7.30	5.30	4.20	3.30	3.40	3.60	3.90	3.30	4.00
13	3.50	5.00	7.50	7.10	5.20	4.10	3.20	4.60	3.50	4.60	3.20	5.20
14	3.30	4.90	8.40	6.90	5.10	4.00	3.20	4.00	3.30	4.60	3.10	4.00
15	3.10	5.10	9.40	6.90	5.00	4.00	5.20	3.80	4.20	4.30	3.20	4.30
16	3.10	5.50	10.70	6.90	5.40	5.80	4.10	4.10	3.80	3.90	3.10	4.10
17	3.20	5.70	18.60	6.80	6.40	5.00	4.00	5.90	3.50	3.60	3.20	3.60
18	3.10	5.40	16.80	11.10	5.70	4.50	3.80	4.10	3.30	3.50	3.50	6.80
19	3.10	5.30	13.40	9.00	5.70	4.80	3.60	3.40	3.30	3.40	4.80	5.80
20	3.20	5.20	11.00	7.60	5.70	4.40	3.40	3.70	3.20	3.40	4.60	4.80
21	3.40	5.90	9.40	7.10	5.20	4.20	3.40	3.40	4.20	3.30	3.90	6.80
22	3.90	6.30	8.90	7.00	5.00	4.00	3.40	3.30	4.10	3.50	3.60	6.60
23	4.20	5.90	8.60	6.60	4.80	3.80	3.80	3.70	3.70	3.20	3.50	6.00
24	3.70	5.30	8.20	6.40	4.70	3.70	3.50	3.60	3.60	3.20	3.30	5.30
25	3.40	7.20	9.10	6.30	4.60	3.70	3.60	3.30	3.40	3.10	3.20	4.80
26	3.40	8.10	8.90	6.20	4.60	3.60	3.50	3.20	6.80	3.10	8.80	4.30
27	3.40	8.40	8.30	6.20	4.50	3.60	4.80	3.20	5.80	3.80	8.50	4.20
28	3.40	19.90	10.00	6.10	4.40	3.50	3.70	3.30	5.30	5.40	5.70	4.00
29	3.30	.....	16.20	5.90	4.30	3.40	4.90	4.30	5.40	4.70	4.40	3.80
30	3.90	.....	17.30	5.80	4.20	3.40	4.70	4.60	5.20	3.90	4.10	4.00
31	4.40	.....	14.60	.....	4.20	.....	4.20	4.70	.....	3.60	.....	4.80

Rating table for Ocmulgee River at Macon, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.2	865	6.6	3,460	10.0	6,820	15.5	20,200
3.4	995	6.8	3,640	10.2	7,060	16.0	22,300
3.6	1,125	7.0	3,820	10.4	7,300	16.5	24,400
3.8	1,260	7.2	4,000	10.6	7,540	17.0	26,500
4.0	1,400	7.4	4,185	10.8	7,780	17.5	28,600
4.2	1,540	7.6	4,375	11.0	8,020	18.0	30,700
4.4	1,685	7.8	4,565	11.2	8,260	18.5	32,800
4.6	1,835	8.0	4,755	11.4	8,510	19.0	34,900
4.8	1,985	8.2	4,945	11.6	8,780	19.5	37,000
5.0	2,140	8.4	5,140	11.8	9,050	20.0	39,100
5.2	2,300	8.6	5,340	12.0	9,400	20.5	41,200
5.4	2,460	8.8	5,540	12.5	10,300	21.0	43,300
5.6	2,620	9.0	5,740	13.0	11,240	21.5	45,400
5.8	2,780	9.2	5,945	13.5	12,470	22.0	47,500
6.0	2,950	9.4	6,155	14.0	13,900		
6.2	3,120	9.6	6,370	14.5	16,000		
6.4	3,290	9.8	6,590	15.0	18,100		

Estimated monthly discharge of Ocmulgee River at Macon, Ga.

[Drainage area, 2,425 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	21,040	800	2,242	0.92	1.06
February	38,680	2,060	8,444	3.48	3.62
March	50,860	4,280	12,700	5.24	6.04
April	10,840	2,780	4,738	1.95	2.18
May	3,290	1,540	2,292	.95	1.10
June	3,120	995	1,631	.67	.75
July	2,300	800	1,169	.48	.55
August	6,260	865	1,624	.67	.77
September	3,680	865	1,377	.57	.64
October	2,620	800	1,430	.59	.68
November	5,540	800	1,423	.59	.66
December	11,950	1,125	2,961	1.22	1.41
The year	50,860	800	3,502	1.44	19.46

OCMULGEE RIVER NEAR FLOVILLA, GA.

A station was established on July 26, 1901, on Ocmulgee River at Lamars Ferry, one-half mile below Lamar's mill and 5 miles east of Flovilla, Ga. The object of this station was to compare the discharge of the river at this point with its discharge below at Macon through the low-water season.

The gage consisted of a ⅛ by 5 inch by 10-foot poplar board graduated to feet and tenths with brass figures, staples, and tacks. The rod was nailed to a 16-foot pine plank, which was spiked to an ash tree 25 feet below the ferry landing. The tree was graduated with nails 1 foot apart, extending the gage up to 20 feet above datum.

The gage and bench marks were washed away by a flood on February 27, 1902, and the station has not been reestablished.

The following discharge measurement was made in 1902:

February 10: Gage height, 5.60 feet; discharge, 2,376 second-feet.

Daily gage height, in feet, of Ocmulgee River near Flovilla, Ga.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1902.			1902.			1902.			1902.		
1	14.00	14.60	9	4.40	5.70	17	3.80	5.50	25	4.00	6.20
2	9.00	19.00	10	4.30	5.60	18	3.70	5.30	26	4.30	7.60
3	6.50	20.20	11	4.10	5.30	19	3.90	5.00	27	4.40	7.60
4	5.70	19.50	12	4.10	5.70	20	4.10	5.50	28	4.10	(a)
5	5.20	10.00	13	4.00	5.00	21	4.20	5.80	29	4.70	.....
6	5.00	8.10	14	3.70	4.80	22	4.70	5.60	30	5.40	.....
7	4.80	7.20	15	3.70	5.20	23	4.50	5.40	31	5.30	.....
8	4.50	6.50	16	4.00	5.70	24	4.20	5.10			

a Gage washed out.

Rating table for Ocmulgee River near Flovilla, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge	Gage height.	Discharge.	Gage height	Discharge
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.6	870	4.4	1,756	6.5	2,837	15.0	7,215
2.8	947	4.6	1,859	7.0	3,095	16.0	7,730
3.0	1,037	4.8	1,962	8.0	3,610	17.0	8,245
3.2	1,138	5.0	2,065	9.0	4,125	18.0	8,760
3.4	1,241	5.2	2,168	10.0	4,640	19.0	9,275
3.6	1,344	5.4	2,271	11.0	5,155	20.0	9,790
3.8	1,447	5.6	2,374	12.0	5,670	21.0	10,305
4.0	1,550	5.8	2,477	13.0	6,185	22.0	10,820
4.2	1,653	6.0	2,580	14.0	6,700	23.0	11,335

Estimated monthly discharge of Ocmulgee River near Flovilla, Ga.

[Drainage area, 1,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	6,700	1,395	2,020	1.35	1.56
February 1–27			3,538	2.36	2.37

ALCOVY RIVER NEAR COVINGTON, GA.

This station was established on April 30, 1901. It is located about 3 miles east of Covington, at a low wooden bridge which is often under water. The gage is a vertical rod 10 feet long, graduated to feet and tenths, marked by tacks and brass figures. It is spiked to a birch tree on the left bank of the river 2 feet from the upstream side of the bridge.

The banks are low and liable to overflow. The ground on the right bank is low and swampy for several hundred yards and is flooded by a moderate rise.

The observer is Stephen Belcher, a farmer living near. This station is above Garners Shoal, on Alcovy River, where the fall is said to be 97 feet in a distance of 1,200 feet. The observer is paid by the Georgia geological survey.

The bench mark is a notch and nail in a maple tree on the right bank, about 15 feet from the upper side of the bridge. Elevation, 5.91 feet above zero of the gage.

The following discharge measurements were made during 1902:

February 7: Gage height, 4.87 feet; discharge, 661 second-feet.
June 14: Gage height, 1.70 feet; discharge, 156 second-feet.
July 18: Gage height, 1.32 feet; discharge, 127 second-feet.
September 12: Gage height, 1.20 feet; discharge, 128 second-feet.

Daily gage height, in feet, of Alcovy River near Covington, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.50	5.20	9.50	5.60	3.00	1.90	1.00	1.80	1.40	2.70	1.60	3.50
2	5.40	7.30	7.20	5.00	3.50	1.40	1.00	1.40	1.30	2.50	1.70	5.00
3	4.80	8.80	6.20	4.80	3.20	2.20	1.00	4.20	1.20	2.00	1.60	5.30
4	4.30	7.00	5.80	4.50	3.00	2.00	2.20	3.70	1.00	1.70	1.90	5.10
5	4.00	6.70	5.30	4.30	2.90	1.90	1.70	5.00	1.00	2.00	2.20	4.90
6	3.70	6.30	5.00	4.20	2.80	1.70	1.70	3.80	1.00	1.90	2.10	4.70
7	3.50	4.90	4.80	4.50	2.70	1.70	1.50	2.50	1.20	1.80	2.00	2.50
8	3.40	4.40	4.60	4.90	2.60	2.50	1.30	2.40	1.10	1.70	2.00	3.20
9	3.30	4.30	4.50	4.70	2.70	3.80	1.20	1.90	1.00	1.60	1.60	3.00
10	3.20	4.00	4.40	4.50	2.60	2.70	1.10	1.50	1.00	1.60	1.60	2.90
11	3.10	3.80	4.30	4.00	2.60	2.20	1.00	1.40	1.00	1.60	1.50	2.70
12	3.00	3.70	4.20	3.80	2.60	2.00	2.50	1.30	1.80	2.20	1.50	2.40
13	2.90	3.60	4.00	3.80	2.50	1.90	2.00	1.00	2.90	2.50	1.50	2.20
14	2.80	3.60	4.40	3.70	2.50	1.80	1.90	1.00	3.30	2.60	1.40	2.20
15	2.70	3.60	4.80	3.70	2.50	2.20	1.80	2.00	2.90	2.10	1.40	2.10
16	2.80	3.80	5.80	3.60	2.60	2.70	1.70	1.90	2.40	1.90	1.60	2.70
17	2.80	3.80	6.80	3.60	2.50	2.50	1.60	1.20	2.00	1.70	1.60	3.00
18	2.70	3.80	6.70	4.30	2.80	2.30	1.40	1.10	1.70	1.50	2.70	3.50
19	2.80	3.70	6.00	4.20	2.70	2.20	1.40	1.30	2.20	1.70	3.20	2.90
20	2.80	3.70	5.70	4.00	2.60	2.10	1.10	1.20	2.80	1.80	2.90	2.40
21	3.00	3.80	5.10	3.90	2.40	1.90	1.10	1.10	2.90	1.60	2.20	3.00
22	3.40	3.80	4.80	3.80	2.60	1.90	1.10	1.00	2.40	1.60	2.00	2.90
23	3.50	3.80	4.50	3.70	2.40	1.80	1.10	1.00	2.10	1.60	1.70	2.80
24	3.00	4.20	4.50	3.70	2.40	1.80	1.10	1.00	1.60	1.60	1.70	2.70
25	3.00	4.30	4.50	3.50	2.30	1.80	1.00	1.00	3.00	1.60	3.30	2.60
26	3.00	4.40	4.30	3.40	2.20	1.80	1.00	1.00	3.00	1.70	4.10	2.40
27	3.00	5.00	3.90	3.00	2.00	1.80	1.00	1.00	3.40	2.10	3.30	2.10
28	3.00	12.80	4.30	3.00	2.00	1.80	2.30	1.20	2.80	2.00	3.00	2.90
29	3.20	.....	5.50	3.00	2.00	1.20	3.50	1.90	2.60	1.90	2.40	2.90
30	3.60	.....	7.40	3.00	2.00	1.20	3.70	2.40	2.80	1.80	2.40	3.00
31	4.00	.....	6.90	.....	2.00	.....	2.80	1.50	.....	1.70	.....	3.00

Rating table for Alcovy River near Covington, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	108	3.0	308	5.0	688	7.0	1,068
1.2	121	3.2	346	5.2	726	7.2	1,106
1.4	136	3.4	384	5.4	764	7.4	1,144
1.6	152	3.6	422	5.6	802	7.6	1,182
1.8	169	3.8	460	5.8	840	7.8	1,220
2.0	187	4.0	498	6.0	878	8.0	1,258
2.2	207	4.2	536	6.2	916	8.5	1,353
2.4	229	4.4	574	6.4	954	9.0	1,448
2.6	252	4.6	612	6.6	992	9.5	1,543
2.8	278	4.8	650	6.8	1,030	.....	.....

Estimated monthly discharge of Alcovy River near Covington, Ga.

[Drainage area, 228 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	973	265	391	1.72	1.98
February	2,170	422	675	2.96	3.08
March	1,543	479	754	3.31	3.82
April	802	308	496	2.18	2.43
May	403	187	251	1.10	1.27
June	460	121	195	.86	.96
July	441	108	163	.71	.82
August	688	108	193	.85	.98
September	384	108	204	.89	.99
October	265	144	181	.79	.91
November	517	136	212	.93	1.04
December	745	197	344	1.51	1.74
The year	2,170	108	338	1.48	20.02

MISCELLANEOUS MEASUREMENTS IN ALTAMAHA DRAINAGE BASIN.

The following miscellaneous measurements were made in the Altamaha drainage basin during 1902 by B. M. Hall and his assistants:

Date.	Stream.	Locality.	Discharge.
			Second-feet.
May 2	Middle Oconee River	Foot of Tallahassee Shoals, 7 miles above Athens gaging station, Georgia.	836.5
June 27	Oconee River	Park's mill, Georgia (minimum stage).	903
July 26	Ocmulgee River	Southern Railway bridge, Lumber City, Ga.	2,368
July 26	Little Ocmulgee River, or Aucheehachee Creek.	¾ mile east of Lumber City, Ga.	285
July 29	Little River	Near Meriwether, Ga.	719
July 30	Oconee River	Milledgeville, Ga. (gage height, 4.8 feet).	3,140
Nov. 17	Ocmulgee River	Pittman's ferry, near Flovilla, Ga.	795
Dec. 17	Little Ocmulgee River, or Aucheehachee Creek.	Near Lumber City, Ga.	1,247
Dec. 17	Alligator Creek	2 miles north of Lumber City, Ga.	279
Dec. 17	Oconee Creek	4 miles from Lumber City, Ga.	461

EASTERN GULF DRAINAGE.

The rivers flowing into the eastern portion of the Gulf of Mexico are for the most part similar in character to those in the Southern Atlantic drainage, though in their lower courses their flow is usually more sluggish. In this report the rivers in this section from which the United States Geological Survey has obtained data during 1902 have been grouped into the following drainage areas: The Apalachicola, the Mobile, and the Pearl.

APALACHICOLA RIVER DRAINAGE BASIN.

Apalachicola River is formed by the union of Flint and Chattahoochee rivers, about 5 miles north of the boundary between Georgia and Florida. It flows across the western part of Florida and empties into the Gulf of Mexico. Chattahoochee River rises in the northeastern part of Georgia and flows in a southwesterly direction until it reaches the Alabama-Georgia State line in the northern part of Harris County, Ga.; hence it flows south, forming the boundary between Alabama and Georgia. Flint River rises in the west-central part of Georgia and flows in a general southerly direction. During 1902 the United States Geological Survey maintained the following stations in this basin, under the direction of B. M. Hall: On the Flint River, at Albany, and near Woodbury, Ga.; on the Chattahoochee River, at Westpoint, at Oakdale, and near Gainesville, Ga.

FLINT RIVER AT ALBANY, GA.

This station was originally established by the United States Weather Bureau on April 10, 1893, and has been maintained from that date to the present. The gage was washed out and replaced in 1898. It was again injured, in 1902, and was replaced by a new gage on June 17, 1902, which was read for the first time on June 18. The new gage was set 9 inches, or seventy-five hundredths of a foot, lower than the old gage. The gage as it existed prior to June 17, 1902, is described in Water-Supply Paper No. 48, on page 156. R. V. Watson was employed by the Weather Bureau to make and set the new gage, and it appears from Mr. Watson's description of this gage on June 17, 1902, that a certain bench mark cut in the lower iron pier of the county bridge and described in Paper No. 48, above referred to, as being 10 feet above zero of gage, was in reality only 9 feet and 3 inches above the zero of the old gage. As Mr. Watson set the new gage 10 feet below this bench mark, its zero is 9 inches lower than that of the old gage. The gage heights have been corrected from January 1 to June 17, 1902, inclusive, to correspond with the new gage, so that one rating table will apply to the whole year.

Albany station is, and has always been, a Weather Bureau station, and John E. Clark has been the observer for years. Discharge measurements were begun by the United States Geological Survey in 1901.

The following is Mr. Watson's description of the present gage: The name of the bridge to which the gage is attached is the Dougherty County Flint River bridge, located at Albany, Ga. The gage is in three parts or sections. No. 1 is attached to the crib around the middle piers (the crib is filled with rocks, being 30 by 14 feet), and extends about 3 feet above ordinary low water. This section reads to 4 feet above zero. It is securely spiked to the wooden crib. Section No. 2 is securely spiked to a green cypress tree just above the bridge on the west bank of the river and shows 17 feet, beginning at 2 feet above the zero on No. 1. No. 3 is securely spiked to a cedar post 16 feet high, the post being put 3 feet into the firm ground. This section begins at 17 feet above the zero on No. 1 and reads to 32 feet, which is about 2½ feet above any high water known since 1840. The gage is subdivided into feet and tenths.

The main bench mark is a chisel cut on the downstream iron pier on the west bank. This cut is 10 feet above the low water of 1888, at which time the river was lower than had been known for years. The zero of the new gage is 10 feet below this bench mark, this being 9 inches lower than originally.

The following discharge measurements were made during 1902 by M. R. Hall and W. E. Hall:

June 25: Gage height, 1.90 feet; discharge, 3,386 second-feet.
June 25: Gage height, 1.90 feet; discharge, 3,440 second-feet.
September 26: Gage height, 1.2 feet; discharge, 2,492 second-feet.
December 4: Gage height, 6.11 feet; discharge, 8,006 second-feet.

Daily gage height, in feet, of Flint River at Albany, Ga., for 1902.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.80	3.80	9.60	8.90	4.80	4.30	2.60	3.00	2.30	2.20	1.80	2.20
2	6.10	5.00	11.80	9.30	4.80	3.60	2.30	3.00	2.00	2.00	1.70	3.60
3	6.70	6.80	15.00	9.80	4.90	2.80	2.00	2.80	1.80	1.80	1.60	4.20
4	6.90	9.00	19.60	9.80	5.10	2.60	2.00	2.40	1.60	1.70	1.70	6.10
5	6.80	11.90	20.90	10.50	5.00	2.50	2.20	2.40	1.60	1.70	1.50	7.30
6	6.60	12.60	22.70	10.80	5.10	2.50	2.10	2.50	1.40	1.80	1.10	7.90
7	7.50	13.30	22.90	9.90	4.80	2.60	1.80	2.80	1.60	1.70	.60	8.20
8	8.30	14.50	19.70	8.80	4.60	2.90	1.70	3.10	1.40	1.30	.40	8.90
9	9.10	14.80	17.60	8.70	3.90	4.10	1.70	3.10	1.80	1.40	.20	9.40
10	9.90	15.90	15.10	7.90	3.70	4.10	1.60	2.90	2.50	1.20	.10	9.90
11	10.80	16.10	11.20	7.80	3.80	4.30	1.40	2.70	3.20	1.00	.40	10.40
12	12.10	14.00	10.40	7.50	3.60	4.50	1.10	2.70	3.20	.90	.60	9.70
13	13.30	11.90	9.80	7.20	3.50	4.50	1.30	2.50	3.40	.80	.90	8.20
14	13.80	10.40	9.50	7.20	3.10	4.90	1.50	2.90	3.40	.70	.90	7.60
15	14.50	7.80	8.90	7.00	2.60	4.80	2.20	3.80	3.60	.70	1.10	6.40
16	14.30	6.90	11.50	7.50	2.50	4.50	2.10	3.60	3.90	.70	.80	6.00

Daily gage height, in feet, of Flint River at Albany, Ga., for 1902—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
17	12.10	6.60	16.30	7.60	2.60	4.90	2.00	3.40	4.30	.60	.60	5.40
18	10.80	6.00	17.00	7.50	3.00	4.30	1.90	3.40	4.40	.70	.40	5.10
19	10.10	7.60	15.60	7.60	3.30	3.90	1.80	3.20	3.90	.50	.40	4.70
20	9.80	7.80	14.10	7.80	3.60	3.70	1.80	3.10	3.70	.40	.30	4.40
21	8.60	8.90	12.80	7.90	3.10	3.10	1.80	2.90	3.90	.90	.10	4.90
22	7.10	9.80	11.70	8.00	2.80	2.80	1.90	2.20	4.10	1.20	.20	5.50
23	6.50	10.30	11.40	8.10	2.50	2.60	2.20	2.10	4.00	1.30	.40	5.70
24	5.10	9.70	10.80	7.90	2.60	2.60	2.60	1.90	4.00	1.80	.40	5.80
25	4.60	8.80	10.70	7.80	3.10	1.90	2.90	1.90	3.20	1.90	.50	6.10
26	4.40	8.10	10.50	7.60	3.50	2.30	2.90	1.80	1.20	2.10	.60	6.30
27	4.30	7.80	9.90	6.80	3.60	2.20	3.20	2.00	2.60	2.00	.90	6.90
28	4.30	7.90	9.60	6.50	3.80	2.20	3.40	2.20	2.40	1.80	.90	7.10
29	4.30	.....	9.60	5.60	4.30	2.00	3.40	2.40	2.20	1.70	1.30	6.60
30	4.20	.....	8.70	4.80	4.60	2.00	3.40	2.40	2.00	1.60	1.80	5.70
31	3.90	.....	7.90	.....	4.60	.....	3.20	2.30	.....	1.90	.....	4.80

Rating table for Flint River at Albany, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	1,495	3.8	5,545	7.4	9,595	11.0	13,645
.4	1,720	4.0	5,770	7.6	9,820	11.5	14,208
.6	1,945	4.2	5,995	7.8	10,045	12.0	14,770
.8	2,170	4.4	6,220	8.0	10,270	12.5	15,333
1.0	2,395	4.6	6,445	8.2	10,495	13.0	15,895
1.2	2,620	4.8	6,670	8.4	10,720	13.5	16,458
1.4	2,845	5.0	6,895	8.6	10,945	14.0	17,020
1.6	3,070	5.2	7,120	8.8	11,170	14.5	17,583
1.8	3,295	5.4	7,345	9.0	11,395	15.0	18,145
2.0	3,520	5.6	7,590	9.2	11,620	15.5	18,708
2.2	3,745	5.8	7,795	9.4	11,845	16.0	19,270
2.4	3,970	6.0	8,020	9.6	12,070	17.0	20,395
2.6	4,195	6.2	8,245	9.8	12,295	18.0	21,520
2.8	4,420	6.4	8,470	10.0	12,520	19.0	22,645
3.0	4,645	6.6	8,695	10.2	12,745	20.0	23,770
3.2	4,870	6.8	8,920	10.4	12,858	21.0	24,895
3.4	5,095	7.0	9,145	10.6	13,195	22.0	26,020
3.6	5,320	7.2	9,370	10.8	13,420	23.0	27,145

Estimated monthly discharge of Flint River at Albany, Ga.

[Drainage area, 5,000 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	17,583	5,658	10,472	2.09	2.41
February	19,383	5,545	12,279	2.46	2.56
March	27,033	10,158	16,251	3.25	3.75
April	13,420	6,670	10,274	2.05	2.29
May	7,008	4,080	5,509	1.10	1.27
June	6,783	3,405	5,020	1.00	1.12
July	5,095	2,505	3,737	.75	.86
August	5,545	3,295	4,296	.86	.99
September	6,220	2,620	4,442	.89	.99
October	3,745	1,720	2,793	.56	.65
November	3,295	1,380	2,176	.44	.49
December	12,970	3,745	8,565	1.71	1.97
The year	27,033	1,380	7,151	1.43	19.35

FLINT RIVER NEAR WOODBURY, GA.

Measurements of the flow of Flint River were made during 1897 and 1898 at Molina, Ga., but the river bed was so shifting that the station was discontinued on June 2, 1898. Two measurements were made in 1899 at the Macon and Birmingham Railroad bridge, near Woodbury, Ga., 5 miles below the Molina station. On March 29, 1900, a gage was put in near this bridge, and the station was reestablished. The gage is a vertical rod, fastened to a willow tree on the left bank of the river about 300 feet above the bridge. The bench mark is the top of the iron girder under the cross-ties at a point 12 feet to the left of the center pier, and is 27 feet above the zero of the gage, the zero of the gage being 659.6 feet above sea level. This gage was maintained by the Georgia geological survey until November 1, 1900, when it was adopted by the United States Weather Bureau instead of the one at Reynolds, Ga. The observer is J. C. Wright, a farmer living near.

This station is at the head of a series of shoals and rapids, having an aggregate fall of 334 feet in a distance of 45 miles, a map and profile of which is published in Twenty-second Annual Report, part 4.

The following discharge measurements were made during 1902:

June 30: Gage height, 0.00 feet; discharge, 292 second-feet.
July 16: Gage height, 1.20 feet; discharge, 1,226 second-feet.
July 31: Gage height, 0.12 foot; discharge, 329 second-feet.
October 6: Gage height, 1.45 feet; discharge, 1,520 second-feet.

Daily gage height, in feet, of Flint River near Woodbury, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.00	3.20	12.00	4.60	1.00	0.40	0.10	0.10	0.40	1.40	1.20	1.80
2	5.00	8.50	11.00	2.90	1.00	.50	.00	.10	.30	1.20	.50	1.70
3	2.90	11.00	9.50	2.30	.90	.80	.00	.00	.20	.90	.40	2.30
4	2.00	9.50	5.40	2.00	.80	.60	.20	.20	.30	.60	.30	3.20
5	1.60	8.00	3.00	1.90	.80	.50	.10	.70	.70	1.10	.40	3.00
6	1.40	3.60	2.50	1.80	.70	.40	.10	1.50	.40	1.60	.50	2.30
7	1.30	2.50	2.30	1.70	.70	.30	.10	1.10	.20	.80	.90	1.60
8	1.20	2.00	2.10	2.80	.70	1.80	.20	.60	.10	.40	1.30	1.30
9	1.20	1.70	1.90	2.70	1.20	.90	.10	.30	.20	.30	.90	1.20
10	1.10	1.60	1.80	2.30	.90	.60	.20	.20	.30	.20	.60	.90
11	1.20	1.50	1.70	1.90	.80	.50	.30	.10	.40	.40	.50	.80
12	1.10	1.40	1.60	1.70	.70	.40	1.90	.30	.20	.60	.40	.90
13	1.00	1.30	1.60	1.50	.60	.30	1.00	.60	.10	.50	.40	1.00
14	.90	1.30	2.00	1.50	.80	.30	.60	.30	.10	.40	.30	.90
15	1.00	1.60	2.30	1.60	.70	.40	.70	.20	.10	.30	.30	.80
16	1.00	1.80	2.80	1.50	1.70	1.00	1.30	.40	.00	.30	.20	1.00
17	1.00	1.80	10.00	1.60	2.30	.80	.70	.20	.00	.20	.40	2.00
18	1.00	1.60	9.00	2.80	1.70	.60	.30	.10	.10	.20	.90	2.90
19	1.00	1.50	6.70	2.40	1.40	.50	.20	.00	.10	.10	.80	3.00
20	1.10	1.60	4.00	1.90	1.20	.40	.10	.00	.00	.10	.80	2.00
21	1.20	1.90	2.50	1.60	.90	.30	.00	.00	.00	.20	.70	1.40
22	1.60	1.80	2.30	1.40	.80	.30	.10	.50	.00	.20	.60	1.50
23	1.50	1.70	2.10	1.30	.70	.30	.10	.20	.00	.10	.50	1.60
24	1.30	1.60	2.00	1.20	.60	.20	.00	.10	.00	.10	.40	1.40
25	1.20	2.00	2.70	1.30	.60	.20	.00	.00	1.50	.00	.40	1.30
26	1.30	2.50	2.50	1.40	.50	.10	.00	.00	1.60	.20	2.90	1.20
27	1.20	2.60	2.40	1.30	1.60	.10	.00	.00	1.50	1.00	2.80	1.10
28	1.20	14.00	4.50	1.20	.50	.10	.00	.50	1.40	1.50	2.00	1.00
29	1.30	.....	8.00	1.10	.40	.10	.10	1.30	1.30	2.00	1.50	1.10
30	1.20	.....	8.50	1.10	.40	.00	.20	1.20	1.80	1.70	1.00	1.20
31	1.50	.....	6.80	.....	.30	.....	.10	.40	.....	1.40	.....	1.30

Rating table for Flint River near Woodbury, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	290	2.6	2,890	5.2	6,880	7.8	12,750
.2	360	2.8	3,150	5.4	7,260	8.0	13,250
.4	470	3.0	3,410	5.6	7,640	8.2	13,750
.6	620	3.2	3,680	5.8	8,040	8.4	14,250
.8	800	3.4	3,960	6.0	8,450	8.6	14,750
1.0	1,005	3.6	4,240	6.2	8,880	8.8	15,250
1.2	1,225	3.8	4,540	6.4	9,320	9.0	15,750
1.4	1,455	4.0	4,840	6.6	9,780	9.2	16,250
1.6	1,685	4.2	5,160	6.8	10,260	9.4	16,750
1.8	1,920	4.4	5,480	7.0	10,750	9.6	17,250
2.0	2,160	4.6	5,820	7.2	11,250	9.8	17,750
2.2	2,400	4.8	6,160	7.4	11,750	10.0	18,250
2.4	2,640	5.0	6,520	7.6	12,250	11.0	21,250

Estimated monthly discharge of Flint River near Woodbury, Ga.

[Drainage area, 988 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	13,250	900	1,891	1.91	2.20
February	30,250	1,340	5,143	5.21	5.43
March	24,250	1,685	6,721	6.80	7.84
April	5,820	1,115	2,042	2.07	2.31
May	2,520	410	934	.95	1.10
June	1,920	290	552	.56	.62
July	2,040	290	470	.48	.55
August	1,570	290	512	.52	.60
September	1,920	290	609	.62	.69
October	2,160	290	752	.76	.88
November	3,280	360	900	.91	1.02
December	3,680	800	1,676	1.70	1.96
The year	30,250	290	1,850	1.87	25.20

CHATTAHOOCHEE RIVER AT WEST POINT, GA.

This station was established on July 30, 1896, by Max Hall, and is at the highway bridge at West Point, Ga., about 1,200 feet above the railroad passenger station. A chain gage is suspended from the

bridge and referred to two bench marks. The first bench mark is the top of the downstream end of the second iron floor beam from the west-bank pier of the highway bridge; elevation, 24.19 feet above datum. The second bench mark is a notch in a large oak tree on the east bank of the river, 100 feet above the wagon bridge; elevation, 19.26 feet. The length of the chain gage is 27.60 feet. The channel is straight and has no obstructions except the piers of the bridge. The flow is sluggish at low stages of water. The banks overflow at high water, but all ordinary stages of water pass through the main channel. The bed of the stream is fairly constant. The observer, E. N. Dunn, is paid by the United States Weather Bureau.

This station is situated at the head of a series of shoals and rapids, having an aggregate fall of 368 feet in a distance of 35 miles, as surveyed under the direction of B. M. Hall in August, 1902.

The following discharge measurements were made during 1902:

January 15: Gage height, 3.50 feet; discharge, 4,364 second-feet.
July 25: Gage height, 2 feet; discharge, 1,916 second-feet.

Daily gage height, in feet, of Chattahoochee River at West Point, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	19.00	7.70	20.00	14.00	4.00	4.60	2.00	3.10	2.80	3.80	2.00	3.60
2	17.60	15.50	17.30	8.30	4.00	3.50	2.00	2.30	2.20	3.20	2.00	3.70
3	8.30	17.10	17.60	6.10	4.70	3.30	1.90	2.10	2.10	2.90	2.00	7.00
4	7.50	14.90	15.90	5.50	4.40	3.10	2.70	2.00	2.20	2.40	2.00	6.70
5	5.10	9.20	8.40	5.30	4.00	2.90	2.50	2.20	3.00	3.00	2.00	7.40
6	4.70	7.50	6.70	5.40	3.90	2.90	2.80	2.40	2.80	3.00	5.70	5.50
7	4.20	5.40	5.90	5.50	3.80	2.80	2.60	3.10	2.40	2.60	4.30	4.40
8	4.10	5.20	5.60	6.20	3.70	2.80	2.40	2.40	2.00	2.60	3.30	3.80
9	4.00	4.70	5.40	5.10	3.80	2.70	2.30	2.10	2.30	2.50	3.30	3.40
10	3.90	4.30	5.20	4.90	4.00	2.70	2.20	1.80	2.60	2.20	2.70	3.20
11	3.80	4.00	5.00	4.70	3.90	2.70	3.20	2.00	2.20	2.20	2.50	3.00
12	3.70	4.00	4.90	4.70	3.80	2.60	3.00	1.80	2.20	2.60	2.40	3.00
13	3.60	4.00	6.30	4.60	3.80	2.60	3.60	2.10	2.30	2.50	2.30	3.00
14	3.40	3.90	5.90	4.50	3.70	2.60	3.40	2.30	2.30	2.70	2.30	3.00
15	3.40	4.60	6.10	4.50	3.60	2.60	3.20	2.00	2.50	2.80	2.20	2.90
16	3.30	5.30	8.70	4.50	4.40	2.50	3.10	1.70	2.50	2.40	2.20	7.00
17	3.30	4.90	16.20	4.50	4.20	2.50	3.00	2.00	2.30	2.40	2.20	10.10
18	3.20	4.40	11.40	5.50	3.90	2.90	3.90	2.10	2.00	2.40	2.40	7.60
19	3.50	4.30	8.80	4.90	3.80	2.70	3.60	1.90	1.90	2.20	2.70	6.10
20	3.90	4.90	7.00	4.70	3.70	2.80	3.30	1.60	1.90	2.10	2.70	4.50
21	5.40	4.50	5.50	4.50	3.60	2.90	3.80	1.60	2.00	2.00	2.70	3.90
22	5.00	4.20	5.30	4.30	3.50	2.80	3.40	1.60	1.90	2.00	2.50	4.50
23	4.30	4.10	4.90	3.90	3.50	2.70	3.30	1.80	2.10	2.00	2.30	4.40
24	3.80	4.00	5.10	3.90	3.40	2.50	3.20	1.50	1.90	2.00	2.30	5.00
25	3.70	4.60	6.00	3.90	3.30	2.40	2.00	1.40	3.00	1.90	2.30	4.10
26	3.70	4.70	6.20	3.80	3.30	2.30	1.90	1.20	3.30	1.90	5.70	3.70
27	3.60	4.90	6.40	3.80	3.30	2.30	1.90	1.30	5.30	3.40	4.90	3.40
28	4.50	18.00	11.40	3.90	3.20	2.20	1.80	1.50	5.00	3.20	4.50	3.30
29	4.10	.....	14.90	3.90	3.10	2.20	2.00	3.00	4.50	2.70	3.50	3.20
30	4.10	.....	14.90	4.00	3.00	2.10	2.20	4.10	3.80	2.20	3.00	3.70
31	4.90	.....	14.60	.....	2.90	.....	2.40	3.00	.....	2.10	.....	4.10

Rating table for Chattahoochee River at West Point, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	935	4.2	5,880	7.4	14,664	10.6	23,940
1.2	1,000	4.4	6,400	7.6	15,240	10.8	24,520
1.4	1,180	4.6	6,940	7.8	15,820	11.0	25,100
1.6	1,380	4.8	7,490	8.0	16,400	12.0	28,800
1.8	1,600	5.0	8,040	8.2	16,980	12.5	31,110
2.0	1,840	5.2	8,592	8.4	17,560	13.0	33,410
2.2	2,100	5.4	9,144	8.6	18,140	13.5	35,710
2.4	2,380	5.6	9,696	8.8	18,720	14.0	38,030
2.6	2,680	5.8	10,248	9.0	19,300	14.5	40,330
2.8	3,000	6.0	10,800	9.2	19,880	15.0	42,630
3.0	3,340	6.2	11,352	9.4	20,460	15.5	44,930
3.2	3,700	6.4	11,904	9.6	21,040	16.0	47,230
3.4	4,080	6.6	12,456	9.8	21,620	17.0	51,830
3.6	4,480	6.8	13,008	10.0	22,200	18.0	56,430
3.8	4,920	7.0	13,560	10.2	22,780	19.0	61,030
4.0	5,370	7.2	14,112	10.4	23,360	20.0	65,630

Estimated monthly discharge of Chattahoochee River at West Point, Ga.

[Drainage area, 3,300 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	61,030	3,700	9,585	2.90	3.34
February	56,430	5,145	13,852	4.20	4.37
March	65,630	7,765	21,982	6.66	7.68
April	38,030	4,920	8,231	2.49	2.78
May	7,215	3,170	4,791	1.45	1.67
June	6,940	1,970	2,962	.90	1.00
July	5,145	1,600	2,988	.91	1.05
August	5,625	1,000	2,061	.62	.71
September	8,868	1,720	2,963	.90	1.00
October	4,920	1,720	2,603	.79	.91
November	9,972	1,840	3,460	1.05	1.17
December	22,490	3,170	7,187	2.18	2.51
The year	65,630	1,000	6,889	2.09	28.19

CHATTAHOOCHEE RIVER AT OAKDALE, GA.

This station was established at Oakdale by Cyrus C. Babb, on October 17, 1895. It is described in the Eighteenth Annual Report, part 4, page 85. It is located at the Southern Railway bridge, 1 mile above the mouth of Proctor Creek and 8 miles northwest of Atlanta.

On July 30, 1896, the location of the station was changed to Mason & Turner's ferry, 1 mile below Oakdale. The gage at this point, known as the "Oakdale lower gage," is nailed to a tree on the right bank, 100 feet below the ferry, and set 1 foot lower than the gage at the Southern Railway bridge. On June 1, 1899, the lower gage was discontinued and the upper gage resumed and adopted by the United States Weather Bureau, the United States Geological Survey still receiving the records and making current-meter discharge measurements at that point. The gage now used is set on the same datum as the old wire gage of the United States Geological Survey, established at that point by Mr. Babb in 1895, and above referred to, but is a vertical timber rod, bolted to the east side of the center pier of the Southern Railway bridge. It is well painted and is graduated to feet with brass figures and to tenths with copper nails from −1.5 feet to +26.5 feet, making its total length 28 feet. Its zero point is 753.5 feet above sea level. Bench mark No. 1 is a railroad spike in the corner of the pier on the right bank, 12.39 feet above datum of gage. The flow is obstructed by rafts, which have to be cleared from the channel occasionally. The channel is straight and the current swift. The banks are subject to overflow. The bed of the stream is constant and the results obtained fairly good.

The observer is Glenn H. Thomas, an employee in the office of the Whittier mills, about 300 yards east of the gage.

Discharge measurements of Chattahoochee River at Oakdale, Ga.

Date.	Hydrographer.	Gageheight.	Discharge.
1902.		*Feet.*	*Second-feet.*
Jan. 14	K. T. Thomas	2.50	2,477
Jan. 25	W. E. Hall	2.50	2,104
Feb. 3	K. T. Thomas	16.70	17,587
Feb. 4	do	7.20	6,573
June 23	W. E. Hall	1.85	1,902
July 10	Max Hall	1.75	1,689
Sept. 16	do	1.10	1,300
Nov. 1	J. C. Conn	.75	1,086
Nov. 20	W. E. Hall	1.12	1,234

Daily gage height, in feet, of Chattahoochee River at Oakdale, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	9.20	7.20	25.00	7.10	3.40	3.20	2.60	2.10	2.40	2.10	0.80	2.40
2	6.00	18.00	20.80	6.40	3.80	3.10	2.60	1.90	2.10	1.50	.70	2.60
3	5.10	19.20	10.30	6.20	3.80	3.10	3.40	1.80	2.10	1.60	.70	7.00
4	4.20	8.60	7.10	5.80	3.60	3.00	2.80	1.80	2.10	1.80	.50	8.60
5	3.70	6.00	7.80	5.20	3.60	2.80	2.60	1.80	2.40	1.50	.50	4.90
6	3.20	4.30	6.00	4.80	3.60	2.80	2.40	1.80	2.30	1.60	.70	4.10
7	3.10	3.20	5.20	4.90	3.60	2.80	2.40	1.90	2.10	2.10	.90	3.30
8	2.80	2.80	4.60	4.90	3.50	2.80	2.10	1.90	2.00	1.80	.80	2.40
9	2.50	2.80	4.40	5.00	3.50	2.80	2.10	1.80	3.50	1.60	1.00	1.90
10	2.30	2.70	4.10	4.40	3.50	2.70	1.80	1.80	3.20	1.50	1.20	1.80
11	2.30	2.70	3.80	4.20	3.60	2.70	1.80	1.90	2.80	1.40	1.30	1.60
12	2.30	2.80	3.60	4.20	3.80	2.70	3.60	1.80	2.30	1.80	1.00	1.60
13	2.30	2.80	5.50	3.80	3.60	2.70	2.40	1.80	2.30	2.10	.90	1.80
14	2.10	2.80	4.80	3.80	3.60	2.60	2.20	1.80	4.80	1.90	.70	1.60
15	2.10	2.80	5.70	3.80	3.60	2.80	2.60	1.70	3.50	1.40	.60	1.70
16	2.10	3.00	11.40	3.60	3.80	5.60	2.40	1.70	2.80	1.60	.80	5.40
17	2.10	3.20	8.00	3.80	3.80	4.20	2.20	1.70	2.40	1.20	.90	7.00
18	2.10	3.10	6.20	4.10	3.80	3.40	2.10	1.70	2.40	1.40	1.30	6.00
19	2.30	2.80	5.60	4.10	3.80	4.00	1.80	1.70	2.60	1.50	1.00	4.00
20	2.20	2.80	4.80	3.80	3.50	3.60	1.80	1.80	2.60	1.60	1.10	2.70
21	2.60	3.00	4.60	3.80	3.50	4.10	2.20	1.80	2.60	1.20	1.00	3.00
22	2.60	3.00	4.40	3.80	3.50	4.40	2.00	1.80	2.40	1.00	.80	2.90
23	2.50	2.80	4.10	3.80	3.40	4.20	1.90	1.60	2.10	.80	.80	2.40
24	2.40	2.80	4.10	3.60	3.20	4.20	1.80	1.60	2.10	.70	.90	2.00
25	2.40	3.60	3.80	3.60	3.20	3.80	1.80	1.60	5.70	.50	1.00	1.80
26	2.40	3.60	3.80	3.60	3.20	3.80	1.80	1.60	5.80	.80	4.80	1.70
27	2.40	3.80	4.20	3.60	3.20	3.00	1.80	1.50	4.60	.90	4.30	1.60
28	2.80	23.20	6.40	3.60	3.20	2.80	2.60	1.80	7.90	1.00	3.60	1.70
29	3.10	.....	21.00	3.40	3.10	2.80	2.70	2.70	5.20	.90	1.90	2.00
30	4.00	.....	21.70	3.50	3.10	2.80	2.50	2.60	3.10	.70	1.60	3.40
31	4.60	.....	9.80	.....	3.10	.....	2.10	2.40	.....	.50	.....	3.00

Rating table for Chattahoochee River at Oakdale, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	1,005	4.4	4,115	8.5	8,790	18.0	19,620
.8	1,120	4.6	4,344	9.0	9,360	18.5	20,190
1.0	1,240	4.8	4,572	9.5	9,930	19.0	20,760
1.2	1,360	5.0	4,800	10.0	10,500	19.5	21,330
1.4	1,490	5.2	5,028	10.5	11,070	20.0	21,900
1.6	1,620	5.4	5,256	11.0	11,640	20.5	22,470
1.8	1,750	5.6	5,484	11.5	12,210	21.0	23,040
2.0	1,890	5.8	5,712	12.0	12,780	21.5	23,610
2.2	2,030	6.0	5,940	12.5	13,350	22.0	24,180
2.4	2,180	6.2	6,168	13.0	13,920	22.5	24,750
2.6	2,335	6.4	6,396	13.5	14,490	23.0	25,320
2.8	2,500	6.6	6,624	14.0	15,060	23.5	25,890
3.0	2,675	6.8	6,852	14.5	15,630	24.0	26,460
3.2	2,855	7.0	7,080	15.0	16,200	24.5	27,030
3.4	3,045	7.2	7,308	15.5	16,770	25.0	27,600
3.6	3,245	7.4	7,536	16.0	17,340	25.5	28,170
3.8	3,450	7.6	7,764	16.5	17,910	26.0	28,740
4.0	3,665	7.8	7,992	17.0	18,480	26.5	29,310
4.2	3,885	8.0	8,220	17.5	19,050	27.0	29,880

Estimated monthly discharge of Chattahoochee River at Oakdale, Ga.

[Drainage area, 1,560 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	9,588	1,960	2,881	1.85	2.13
February	25,548	2,415	5,306	3.40	3.54
March	27,600	3,245	8,024	5.14	5.93
April	7,194	3,045	4,065	2.61	2.91
May	3,450	2,765	3,150	2.02	2.33
June	5,484	2,335	3,004	1.93	2.15
July	3,245	1,750	2,113	1.35	1.56
August	2,415	1,555	1,786	1.14	1.31
September	8,106	1,890	2,938	1.88	2.10
October	1,960	950	1,470	.94	1.08
November	4,572	950	1,481	.95	1.06
December	8,904	1,620	3,032	1.94	2.24
The year	27,600	950	3,271	2.10	28.34

CHATTAHOOCHEE RIVER NEAR GAINESVILLE, GA.

This station was established on June 26, 1901, 3½ miles northwest of Gainesville, at Thompson's bridge.

The gage is a 15-foot vertical rod, graduated to feet and tenths. It is on the right bank about 50 feet below the bridge. The bridge is a three-span wooden structure supported on stone piers. At low water nearly the whole of the river flows through the center span, which is 100 feet long. It is entirely housed in, but holes are cut in the floor along the upstream side at intervals of 12 feet, through which the meter can be lowered for gaging.

The bench mark is the top of the main bridge stringer at the left side of the first stone pier, in the river, from the left bank, and is 31 feet above datum.

The observer, Homer D. Thompson, moved away on September 27, 1902, without giving notice, and another observer could not be secured until December 28, 1902. On that date Jack Elrod was employed.

Discharge measurements of Chattahoochee River near Gainesville, Ga.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
February 7	K. T. Thomas	3.65	1,482
May 3	W. E. Hall	3.80	1,241
July 11	B. M. Hall	2.58	704
October 11	J. C. Conn	2.80	715
November 24	W. E. Hall	2.33	520

Daily gage height, in feet, of Chattahoochee River near Gainesville, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.00	4.90	14.00	5.50	3.10	3.50	2.30	3.10	4.20	.....	.....	.....
2	6.40	15.60	6.00	5.30	3.40	3.40	2.00	3.00	4.00	.....	.....	.....
3	6.30	10.40	5.90	5.00	4.60	3.20	7.90	4.20	4.50	.....	.....	.....
4	6.00	9.30	5.60	4.60	4.50	3.00	6.30	3.60	4.50	.....	.....	.....
5	5.60	6.10	5.00	4.20	4.20	3.00	4.20	2.80	4.60	.....	.....	.....
6	4.20	5.00	4.90	4.00	4.00	2.90	4.20	2.60	4.80	.....	.....	.....
7	3.60	4.10	4.80	3.90	4.60	2.90	4.00	3.00	4.50	.....	.....	.....
8	3.40	4.00	6.80	3.90	4.80	2.80	4.00	2.80	4.30	.....	.....	.....
9	3.40	3.90	5.60	3.60	4.30	2.80	3.80	3.10	4.90	.....	.....	.....
10	3.40	3.80	5.30	3.40	5.00	3.00	3.60	4.00	4.60	.....	.....	.....
11	3.30	3.60	5.00	3.40	4.90	3.00	3.50	4.60	4.80	.....	.....	.....
12	3.20	3.50	4.80	3.40	4.60	2.90	3.20	4.00	4.60	.....	.....	.....
13	3.20	3.60	4.60	3.30	4.30	2.90	3.00	3.60	4.50	.....	.....	.....
14	3.10	3.50	4.20	3.20	4.00	2.80	4.00	3.60	4.20	.....	.....	.....
15	3.00	3.30	4.60	3.10	4.00	2.80	3.80	3.60	4.60	.....	.....	.....
16	3.00	3.20	6.30	3.20	4.00	2.90	2.90	3.10	4.80	.....	.....	.....

Daily gage height, in feet, of Chattahoochee River near Gainesville, Ga.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
17	2.90	3.10	5.60	3.80	4.00	3.00	4.60	3.60	4.00	.....	.....	.....
18	2.80	3.20	4.30	3.90	4.00	4.00	4.00	3.10	4.20	.....	.....	.....
19	2.80	3.30	4.20	3.50	4.10	3.80	3.60	3.60	4.60	.....	.....	.....
20	2.70	3.40	4.00	3.60	4.00	3.60	3.50	2.80	4.80	.....	.....	.....
21	2.60	3.00	4.00	3.40	3.90	4.20	3.40	2.80	4.60	.....	.....	.....
22	2.60	3.00	3.90	3.20	3.40	4.00	4.20	3.10	4.80	.....	.....	.....
23	2.60	2.90	3.80	3.80	6.00	4.00	3.60	4.00	4.00	.....	.....	.....
24	3.60	2.90	3.60	3.60	5.30	3.80	4.00	4.60	3.60	.....	.....	.....
25	3.80	2.90	3.60	3.40	5.00	3.40	3.10	4.00	3.70	.....	.....	.....
26	3.80	3.00	3.50	3.40	4.80	3.40	2.60	4.60	4.00	.....	.....	.....
27	3.70	6.00	7.60	3.40	4.60	3.40	2.50	4.00	4.60	.....	.....	.....
28	3.60	26.40	15.60	3.50	4.30	2.80	3.00	3.60	(a)	.....	.....	4.00
29	3.60	.....	18.40	3.40	4.00	2.80	4.00	4.20	.....	.....	.....	3.90
30	3.50	.....	10.60	3.20	3.60	2.40	3.40	4.20	.....	.....	.....	3.80
31	4.60	.....	6.40	.....	3.50	.....	2.80	4.60	.....	.....	.....	3.70

a Observer absent from September 28 to December 27.

Rating table for Chattahoochee River near Gainesville, Ga., for 1901 and 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	350	5.6	2,690	9.2	5,030	14.0	8,150
2.2	480	5.8	2,820	9.4	5,160	15.0	8,800
2.4	610	6.0	2,950	9.6	5,290	16.0	9,450
2.6	740	6.2	3,080	9.8	5,420	17.0	10,100
2.8	870	6.4	3,210	10.0	5,550	18.0	10,750
3.0	1,000	6.6	3,340	10.2	5,680	19.0	11,400
3.2	1,130	6.8	3,470	10.4	5,810	20.0	12,050
3.4	1,260	7.0	3,600	10.6	5,940	21.0	12,700
3.6	1,390	7.2	3,730	10.8	6,070	22.0	13,350
3.8	1,520	7.4	3,860	11.0	6,200	23.0	14,000
4.0	1,650	7.6	3,990	11.2	6,330	24.0	14,650
4.2	1,780	7.8	4,120	11.4	6,460	25.0	15,300
4.4	1,910	8.0	4,250	11.6	6,590	26.0	15,950
4.6	2,040	8.2	4,380	11.8	6,720	27.0	16,600
4.8	2,170	8.4	4,510	12.0	6,850	28.0	17,250
5.0	2,300	8.6	4,640	12.5	7,175	29.0	17,900
5.2	2,430	8.8	4,770	13.0	7,500	30.0	18,550
5.4	2,560	9.0	4,900	13.5	7,825	31.0	19,200

Estimated monthly discharge of Chattahoochee River near Gainesville, Ga.

[Drainage area, 544 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
June 26–30			1,975	3.63	0.68
July	4,640	870	1,520	2.79	3.22
August	8,800	805	2,724	5.01	5.78
September	6,200	1,130	1,912	3.51	3.92
October	1,715	1,000	1,327	2.44	2.81
November	1,000	480	792	1.46	1.63
December	17,510	545	2,342	4.31	4.97
1902.					
January	4,250	740	1,530	2.81	3.24
February	16,210	935	2,553	4.69	4.88
March	11,010	1,325	3,086	5.67	6.54
April	2,625	1,065	1,479	2.72	3.03
May	2,950	1,065	1,835	3.37	3.89
June	1,780	610	1,139	2.09	2.33
July	4,185	350	1,461	2.69	3.10
August	2,040	740	1,388	2.55	2.94
September 1–27			1,922	3.53	3.55
December 28–31			1,552	2.85	.42

MISCELLANEOUS MEASUREMENTS IN APALACHICOLA RIVER DRAINAGE BASIN.

The following miscellaneous measurements were taken in the Apalachicola drainage basin during 1902 by B. M. Hall and his assistants:

Date.	Stream.	Locality.	Discharge.
			Second-feet.
June 10	Chattahoochee River	Medlocks bridge, 4 miles north of Norcross, Ga. (gage height, 2.42 feet).	1,674
25	Kinchafoonee Creek	Albany, Ga. (gage height, 1.15 feet).	477
25	Muckalee Creek	Albany, Ga. (gage height, 0.97 foot).	746
26	Sweetwater Creek	Strickland's bridge, Austell, Ga.	80
27	Peachtree Creek	River Park, near Atlanta, Ga	60
July 11	Little River	Below Dunlap's mill, near Gainesville, Ga.	86
22	Chestatee River	Ferry at mouth, near Gainesville, Ga	266
24	Chattahoochee River	Flowery Branch, Ga. (gage height, 2.65 feet).	967

Date.		Stream.	Locality.	Discharge.
				Second-feet.
July	30	Standingboy Creek	Columbus, Ga., half mile above mouth.	5
	30	Roaring Creek	Near Columbus, Ga., one-fourth mile above mouth.	1
Sept.	25	Sweetwater Creek	Strickland's bridge, near Austell, Ga. (gage height, 2.15 feet).	188
	27	Muckalee Creek	Albany, Ga. (gage height, 0.90 foot)	690
	27	Kinchafoonee Creek	Albany, Ga. (gage height, 1.20 feet)	499
Oct.	3	Sweetwater Creek	Strickland's bridge, near Austell, Ga. (gage height, 1.53 feet).	119
	31	Chattahoochee River	Plant System R. R. bridge, Alaga, Ala.	9,634
Dec.	4	Kinchafoonee Creek	Albany, Ga. (gage height, 2.40 feet)	1,196
	4	Muckalee Creek	Albany, Ga. (gage height, 2.50 feet)	2,180

MOBILE RIVER DRAINAGE BASIN.

This is the largest drainage basin in Georgia and Alabama, and is designated the Mobile Basin because its waters all enter the Gulf through Mobile River at Mobile, Ala. It is formed as follows: Beginning at the headwaters, the Cartecay and Ellijay rivers unite at Ellijay, Ga., to form the Coosawattee River. Just above Resaca, Ga., this unites with the Conasauga to form Oostanaula River. At Rome, Ga., the Oostanaula and the Etowah unite to form Coosa River. Six miles above Montgomery, Ala., the Coosa and the Tallapoosa unite to form the Alabama River; and not far from the coast the Tombigbee unites with the Alabama to form the Mobile River, which flows into Mobile Bay, an arm of the Gulf of Mexico.

Cahaba River is the principal tributary of the Alabama and joins it about 10 miles below Selma. Hillabee Creek flows into Tallapoosa River just above Sturdevant and near Alexander. Talladega Creek is a tributary of the Coosa.

Tombigbee River rises in the northeastern part of Mississippi and enters Alabama in Pickens County. Its principal tributary is the Black Warrior, which is formed by the junction of Mulberry Fork and Lipsey Fork. Locust Fork enters the Black Warrior some distance below the junction. During 1902 the following stations were maintained in this basin under the supervision of B. M. Hall: On the Cahaba at Centerville, Ala.; on the Alabama at Selma and at Montgomery, Ala.; on the Tallapoosa at Milstead and at Sturdevant, Ala.; on Hillabee Creek near Alexander, Ala.; on Talladega Creek at Nottingham, Ala.; on the Coosa at Riverside, Ala.; on the Black Warrior at Tuscaloosa and near Cordova, Ala.; on the Black Warrior (Locust Fork) at Palos, Ala.; on the Coosa at Rome, Ga.; on the Etowah at Canton, Ga.; on the Coosawattee at Carters, Ga.; on the Tombigbee at Columbus, Miss.

CAHABA RIVER AT CENTERVILLE, ALA.

The station was established on August 7, 1901, and is situated at the iron highway bridge one-fourth mile west of Centerville, Ala. The bridge is a single span supported by tubular iron piers.

The gage is a wire fastened to the timber fencing along the downstream side of the bridge. The pulley is 100 feet from the initial point, which is the end of the iron bridge on the left bank, downstream side. The bench mark is the top of the iron crossbeam, under the bridge floor, nearest the gage pulley, and is 42.85 feet above the datum of gage. The observer is Clyde Lowrey.

It was the intention of the Geological Survey to discontinue this station and find a better section, but it will be given another year's trial with the hope of getting better results.

The following discharge measurements were made during 1902:

January 25: Gage height, 5.15 feet; discharge, 1,707 second-feet.
April 7: Gage height, 8.60 feet; discharge, 2,823 second-feet.
July 9: Gage height, 2.40 feet; discharge, 251 second-feet.

Daily gage height, in feet, of Cahaba River at Centerville, Ala.

Day.	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	13.60	16.80	24.00	15.40	4.90	2.80	2.30	2.20	2.30	2.40	2.00	3.00
2	9.00	24.60	18.20	12.10	4.50	2.80	2.30	2.80	2.30	2.60	2.00	2.50
3	6.90	21.20	13.30	11.40	4.00	2.70	2.20	2.50	3.30	2.60	2.00	2.90
4	5.70	16.60	9.80	10.90	3.70	2.60	2.20	2.50	3.20	2.50	2.00	3.10
5	4.90	10.60	12.00	10.40	3.60	2.60	2.20	2.40	2.90	2.40	2.00	5.60
6	4.50	8.30	12.10	8.60	3.50	2.50	2.20	2.40	2.40	2.20	2.00	5.10
7	4.10	7.30	8.70	8.20	3.60	2.50	2.20	2.30	2.30	2.20	2.90	4.90
8	3.90	6.70	8.30	13.60	3.50	2.40	2.20	2.30	2.30	2.20	2.40	4.20
9	3.70	5.80	7.90	12.20	3.40	2.30	2.30	2.30	2.20	2.70	2.40	3.90
10	3.40	5.40	7.60	9.60	3.40	2.30	2.50	2.30	2.20	2.80	2.30	3.60
11	3.20	5.10	6.30	8.00	3.30	2.40	2.90	2.30	2.20	10.80	2.30	3.20
12	3.00	4.80	6.10	7.20	3.30	2.40	3.50	2.20	2.10	7.10	2.20	3.00
13	2.90	4.30	5.90	6.90	3.40	2.30	3.30	2.10	2.10	5.40	2.20	3.00
14	2.70	5.70	5.20	6.50	3.50	2.30	3.20	2.10	2.00	3.40	2.20	3.00
15	2.60	5.90	6.20	6.10	4.10	2.30	2.60	2.10	2.00	3.20	2.10	3.90
16	2.40	6.30	22.30	5.60	8.40	2.30	2.40	2.10	2.00	3.00	2.20	15.30
17	2.30	5.60	22.20	5.90	8.40	2.30	2.20	2.10	2.00	2.90	2.20	13.50
18	3.10	5.30	17.30	5.70	5.30	2.20	2.20	2.10	2.00	2.90	2.30	12.70
19	3.60	4.90	11.10	5.60	4.30	2.30	2.20	2.10	2.00	2.60	2.40	9.90
20	3.90	4.80	8.60	5.20	4.20	2.50	2.30	2.10	2.10	2.50	2.20	7.50
21	4.60	5.10	8.90	4.90	4.20	2.40	2.40	2.10	2.10	2.50	2.20	6.30
22	6.90	5.10	9.10	4.60	3.90	2.60	2.30	2.10	2.00	2.40	2.20	7.80
23	5.80	5.00	7.30	4.50	3.60	2.50	2.20	2.10	2.00	2.30	2.20	8.20
24	5.10	5.10	7.80	4.50	3.50	2.40	2.20	2.10	2.00	2.20	2.20	10.30
25	5.00	5.90	13.60	4.40	3.30	2.40	2.20	2.10	2.00	2.20	2.20	7.30
26	4.90	6.50	11.90	4.30	3.20	2.40	2.10	2.10	2.00	2.10	2.90	6.50
27	6.20	8.10	28.80	4.20	3.00	2.40	2.10	2.20	2.10	2.10	3.40	5.10
28	7.00	27.60	35.00	4.10	2.90	2.30	2.10	2.30	2.30	2.00	4.20	4.90
29	8.30	.....	29.20	4.30	2.80	2.30	2.10	2.50	2.20	2.00	3.50	4.50
30	8.10	.....	25.20	4.90	2.80	2.30	2.20	2.60	3.00	2.00	3.20	4.10
31	11.60	.....	24.00	.....	2.90	.....	2.20	2.50	.....	2.00	.....	4.90

Rating table for Cahaba River at Centerville, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	245	4.6	1,510	11.5	3,925	20.5	7,075
1.2	320	4.8	1,580	12.0	4,100	21.0	7,250
1.4	390	5.0	1,650	12.5	4,275	22.0	7,600
1.6	460	5.2	1,720	13.0	4,450	23.0	7,950
1.8	530	5.4	1,790	13.5	4,625	24.0	8,300
2.0	600	5.6	1,860	14.0	4,800	25.0	8,650
2.2	670	5.8	1,930	14.5	4,975	26.0	*9,000
2.4	740	6.0	2,000	15.0	5,150	27.0	9,350
2.6	810	6.5	2,175	15.5	5,325	28.0	9,700
2.8	880	7.0	2,350	16.0	5,500	29.0	10,050
3.0	950	7.5	2,525	16.5	5,675	30.0	10,400
3.2	1,020	8.0	2,700	17.0	5,850	31.0	10,750
3.4	1,090	8.5	2,875	17.5	6,025	32.0	11,100
3.6	1,160	9.0	3,050	18.0	6,200	33.0	11,450
3.8	1,230	9.5	3,225	18.5	6,375	34.0	11,800
4.0	1,300	10.0	3,400	19.0	6,550	35.0	12,150
4.2	1,370	10.5	3,575	19.5	6,725		
4.4	1,440	11.0	3,750	20.0	6,900		

Estimated monthly discharge of Cahaba River at Centerville, Ala.

[Drainage area, 1,040 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	4,660	705	1,739	1.67	1.93
February	*9,560	1,405	2,955	2.84	2.96
March	12,150	1,720	4,799	4.61	5.31
April	5,290	1,335	2,464	2.37	2.64
May	2,840	880	1,282	1.23	1.42
June	880	670	749	.72	.80
July	1,125	635	730	.70	.81
August	880	635	690	.66	.76
September	1,055	600	689	.66	.74
October	3,680	600	939	.90	1.04
November	1,370	600	746	.72	.80
December	5,255	775	1,974	1.90	2.19
The year	12,150	600	1,646	1.58	21.40

ALABAMA RIVER AT SELMA, ALA.

This station was originally established by the United States Engineer Corps; readings are now taken by the United States Weather Bureau. The gage, which is attached to the iron highway bridge, the floor of which is about 60 feet above low water, is in two sections. The lower section, which reads from −3.0 feet to +2.30 feet, is secured to the pile on the lower side of the cofferdam on the draw pier; the upper section, which reads from 2.30 feet to 48 feet, is attached to the same pier. The bench mark, which is an iron bolt driven into the face of a rock bluff 182 feet from the first bridge pier, on the road ascending to the city, is 26 feet above the zero of the gage and 87.30 feet above mean sea level. The top of the coping stone of the pivot pier at the highway bridge to which gage is attached is 56 feet above the zero of the gage and 117.30 feet above mean sea level.

Daily gage height, in feet, of Alabama River at Selma, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	41.00	16.80	34.30	50.10	8.40	3.60	1.50	0.40	3.50	3.70	1.40	6.00
2	45.00	23.00	41.50	50.70	8.70	3.50	1.20	.40	3.70	5.20	.80	6.30
3	46.60	29.80	45.20	50.00	8.40	3.50	1.00	.70	3.00	5.00	.70	8.80
4	46.30	35.00	47.10	48.60	7.80	4.00	1.00	.80	3.80	4.00	.50	10.50
5	41.40	37.50	47.10	46.00	7.40	4.00	.90	.90	3.00	3.60	.20	13.60
6	37.00	37.90	46.20	42.40	7.00	3.80	.80	1.10	3.00	3.00	.40	14.00
7	35.00	37.90	44.40	39.00	7.00	3.50	.70	1.40	2.50	2.80	.80	14.20
8	33.00	37.00	43.00	35.60	7.00	3.20	.60	1.30	2.20	2.50	3.90	13.70
9	30.00	34.00	41.80	32.00	6.90	2.90	.60	1.10	2.00	2.50	4.80	12.00
10	25.40	30.00	39.00	28.90	6.80	2.90	.60	1.10	1.20	1.00	4.00	9.80
11	17.00	24.00	35.10	25.60	6.70	2.90	1.00	1.50	.90	2.00	2.80	7.80
12	14.90	17.60	30.00	22.00	6.50	2.80	1.10	1.50	.80	2.00	1.90	7.20
13	10.10	14.00	25.50	19.00	6.30	2.60	1.10	1.10	.70	4.00	1.50	5.30
14	9.00	11.70	21.00	16.20	6.00	2.50	1.80	.90	.60	6.00	1.40	4.20
15	8.10	11.60	19.20	14.60	5.80	2.50	1.90	.80	.20	5.80	.90	3.80
16	7.50	12.00	19.80	14.20	6.00	2.80	1.90	.80	.00	5.00	.70	7.60
17	7.00	12.30	23.00	13.00	7.40	2.60	1.90	.70	−.10	4.60	.50	13.80
18	6.50	13.00	28.00	12.20	8.70	2.40	1.90	.60	−.20	4.50	.50	21.50
19	6.50	12.00	32.00	12.80	9.50	2.30	1.90	.10	−.30	4.00	.70	25.50
20	6.50	11.80	33.60	13.20	9.00	2.20	2.00	.00	−.30	2.00	.90	25.60
21	8.00	11.80	33.80	13.00	8.60	2.10	2.10	−.10	.00	1.80	1.40	22.00
22	8.10	11.90	29.80	13.00	7.80	2.00	2.50	−.20	.00	1.40	1.50	17.00
23	9.00	12.00	26.00	11.40	6.60	2.00	2.40	−.30	−.10	1.00	1.50	15.00
24	12.00	12.20	23.00	10.60	5.90	2.00	1.80	−.20	−.20	1.00	1.30	15.00
25	13.80	12.00	22.80	10.00	5.40	1.90	1.00	−.40	−.20	.90	1.70	15.00
26	13.00	12.00	24.00	9.80	5.40	1.90	.80	−.30	−.20	.60	2.60	14.00
27	11.50	14.00	24.90	9.40	5.00	1.80	.60	−.40	.20	.20	4.80	12.80
28	11.40	23.60	30.00	9.00	4.80	1.80	.50	−.20	.20	.00	7.60	10.90
29	12.00	.....	38.00	8.60	4.40	1.80	.40	.10	.50	−.10	6.90	9.00
30	14.60	.....	45.10	8.50	4.00	1.70	.50	.20	.90	1.20	5.80	7.00
31	16.00	.....	48.90	.....	3.80	.....	.50	.40	.....	1.80	.....	6.40

Rating table for Alabama River at Selma, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
-0.4	6,470	3.6	11,092	11.5	31,490	28.0	75,380
-.2	6,575	3.8	11,448	12.0	32,820	29.0	78,040
.0	6,700	4.0	11,820	12.5	34,150	30.0	80,700
.2	6,845	4.2	12,220	13.0	35,480	31.0	83,360
.4	7,009	4.4	12,660	13.5	36,810	32.0	86,020
.6	7,189	4.6	13,150	14.0	38,140	33.0	88,680
.8	7,384	4.8	13,668	14.5	39,370	34.0	91,340
1.0	7,596	5.0	14,200	15.0	40,800	35.0	94,000
1.2	7,818	5.5	15,530	16.0	43,460	36.0	96,660
1.4	8,045	6.0	16,860	17.0	46,120	37.0	99,320
1.6	8,276	6.5	18,190	18.0	48,780	38.0	101,980
1.8	8,511	7.0	19,520	19.0	51,440	39.0	104,640
2.0	8,750	7.5	20,850	20.0	54,100	40.0	107,300
2.2	8,996	8.0	22,180	21.0	56,760	41.0	109,960
2.4	9,256	8.5	23,510	22.0	59,420	42.0	112,620
2.6	9,532	9.0	24,840	23.0	62,080	43.0	115,280
2.8	9,822	9.5	26,170	24.0	64,740	44.0	117,940
3.0	10,120	10.0	27,500	25.0	67,400	45.0	120,600
3.2	10,428	10.5	28,830	26.0	70,060	46.0	123,260
3.4	10,752	11.0	30,160	27.0	72,720	47.0	125,920

Estimated monthly discharge of Alabama River at Selma, Ala.

[Drainage area, 15,400 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	124,856	18,190	52,655	3.42	3.94
February	101,714	31,756	54,898	3.56	3.71
March	130,974	51,972	90,404	5.87	6.77
April	135,762	23,510	62,017	4.03	4.49
May	26,170	11,448	18,859	1.22	1.41
June	11,820	8,393	9,682	.63	0.70
July	9,392	7,009	7,897	.51	.59
August	8,160	6,470	7,176	.47	.54
September	11,448	6,520	7,871	.51	.57
October	16,860	6,635	10,184	.66	.76
November	21,116	6,845	9,557	.62	.69
December	68,996	11,448	33,122	2.15	2.48
The year	135,762	6,470	30,360	1.97	26.65

ALABAMA RIVER AT MONTGOMERY, ALA.

This river, as described in the United States Weather Bureau reports, is formed by the junction of Coosa and Tallapoosa rivers, 6 miles above Montgomery. A gage rod was established by the United States Engineer Corps a number of years ago at the Montgomery wharf, near the union passenger station at the foot of Commerce street. The readings are now taken by the Weather Bureau and are furnished to this Survey. The gage rod is in six sections, as follows: Section 1, from −2 to +10 feet, on the fender pile at the face of the wharf, 108 feet from the lower end; section 2, from 10 to 15 feet, at the upper end of the pile protection to the Louisville and Nashville Railroad bank at the corner pile, the 15-foot mark being 1.1 feet above the top of the pile; section 3, 15 to 27 feet, on the bent in the center of the drain, on the lower side of the Commerce street sewer; section 4, 27 to 36 feet, on the upper side of the sewer, on the third bent; section 5, 36 to 46 feet, on the same side of the sewer, on the sixth bent; section 6, 46 to 50 feet, on the same side of the sewer, on the seventh bent. The rods are of pine timber, painted, and graduated to feet and tenths. There are also two new sections, 15 to 25 feet and 25 to 37 feet, on trees about 50 yards south of the old gage. The bench mark is the northeast corner of the stone doorsill in the north door of Windsor Hotel, on Commerce street. It is 59.7 feet above the zero of the gage, and is 163.4 feet above sea level. The high-water mark for Montgomery is

59.7 feet, and was reached in April, 1886. The danger line is placed at 35 feet. The width of the river at low water is 690 feet. The only point where measurements can be made is at the iron bridge of the Louisville and Nashville Railroad, about 3 miles above Montgomery. This bridge is 60.6 feet above low water, with three spans over the river, the center one being a draw or turn span.

Daily gage height, in feet, of Alabama River at Montgomery, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	45.80	15.00	38.50	47.00	6.70	2.70	1.00	0.40	2.70	6.60	0.50	4.80
2	44.90	24.50	46.40	44.50	6.00	2.90	1.00	.50	2.50	5.60	.30	4.70
3	42.50	32.40	46.70	41.40	5.70	3.00	.80	.70	2.50	3.20	.20	7.20
4	39.50	36.50	45.50	38.00	5.30	2.90	.70	.90	2.20	2.80	.10	10.90
5	36.00	37.60	41.70	34.50	5.30	2.90	.60	1.00	1.60	2.40	.20	11.60
6	31.50	36.00	39.00	30.50	5.40	2.50	.60	.80	1.10	2.00	1.10	11.80
7	28.40	32.80	37.50	25.50	5.30	2.30	.60	1.00	1.00	1.70	3.80	11.30
8	25.60	29.00	34.20	20.50	5.00	2.30	.60	.70	1.00	1.30	4.10	9.70
9	21.00	25.00	31.40	20.00	4.80	2.30	.70	1.00	1.00	.90	3.00	7.60
10	15.00	18.60	28.70	18.80	4.90	2.30	.50	1.40	.90	.50	2.10	5.80
11	8.60	13.00	23.80	16.00	4.70	2.20	.50	1.10	.80	.80	1.50	4.60
12	6.50	9.40	17.80	14.50	4.40	2.10	.60	.80	.60	4.00	1.50	3.80
13	6.10	8.00	14.50	12.00	4.20	2.10	.80	.70	.40	4.50	1.30	3.30
14	5.60	7.60	14.00	11.50	3.90	2.00	1.20	.90	.20	4.40	.90	3.00
15	5.30	7.80	13.80	10.00	4.00	1.80	1.30	.50	.10	4.00	.60	2.70
16	5.00	9.00	15.50	9.80	5.30	1.80	1.50	.50	.10	3.30	.50	4.20
17	4.80	9.80	23.00	9.00	7.00	1.80	1.50	.40	.10	2.70	.50	17.30
18	4.60	9.50	28.30	9.80	7.40	1.60	1.70	.20	.00	2.20	.60	20.60
19	4.60	8.50	30.10	10.30	7.40	1.60	1.70	.20	−.10	1.60	1.10	21.20
20	4.90	8.20	28.20	10.00	7.20	1.60	2.00	.10	.30	1.20	1.30	17.50
21	5.30	8.40	24.00	9.00	5.60	1.60	2.00	.00	.20	1.00	1.30	12.00
22	7.00	8.80	20.00	8.70	4.80	1.60	1.60	.00	.00	1.00	1.20	10.40
23	8.00	8.60	17.50	8.00	4.50	1.60	1.10	.10	−.10	1.00	1.10	12.00
24	10.20	8.20	14.50	7.50	4.00	1.60	.80	.00	.20	.70	1.30	12.50
25	9.50	8.80	17.50	7.00	4.00	1.50	.60	−.10	.10	.40	1.20	11.60
26	8.70	9.80	19.50	7.00	3.70	1.50	.40	.00	.00	.20	3.70	10.20
27	8.00	10.20	18.50	6.50	3.40	1.30	.40	.30	+.50	.10	6.30	8.40
28	7.90	25.60	32.00	6.20	3.30	1.30	.30	.50	.60	.20	5.10	6.60
29	10.90	.....	41.40	6.00	3.20	1.20	.30	.50	1.20	1.50	4.40	5.50
30	12.50	.....	45.80	6.00	3.00	1.00	.20	1.50	3.90	1.70	4.60	5.00
31	13.00	.....	47.80	.....	2.70	.....	.20	3.50	.....	1.10	.....	5.50

TALLAPOOSA RIVER AT MILSTEAD, ALA.

A gaging station was established on August 7, 1897, at the bridge of the Tallassee and Montgomery Railway, about one-fourth of a mile from Milstead, Ala. The bridge is of iron, two spans of about 155 feet each, with short wooden trestles at each end. The initial point of measurement is the end of the iron bridge, on the left bank, downstream side. The rod of the wire gage is fastened to the outside of the guard rail on the downstream side of the bridge. The bench mark is the top of the second crossbeam from the left bank pier at the downstream end, and is 60 feet above datum. The channel is straight at the bridge and bends above and below. The current is

sluggish at low water and obstructed by the center pier of the bridge. The banks are high, but overflow at extreme high water for several hundred feet on each side. The bed is fairly constant, and all the water is confined to the main channel by railroad embankments.

During the year 1902 there have been three different observers—Seth Johnson until April 6, B. F. Wells until October 27, and W. F. McGee from November 20 to the end of the year. Mr. McGee failed to begin at the time that Mr. Wells left off, as he was expected to do.

The large new dams at Tallassee Falls—6 and 9 miles, respectively, above this station—almost stop the flow of the river at certain times, so that discharge measurements at Milstead do not represent the amount of water furnished by the stream. On August 21 to 27, and and on October 19, 20, 24, 25, and 26, the dams were evidently impounding water. The station at Sturdevant, Ala., about 30 miles above these dams, has been established to replace Milstead.

The following discharge measurement was made in 1902:

January 14: Gage height, 3.65 feet; discharge, 3,644 second-feet.

Daily gage height, in feet, of Tallapoosa River at Milstead, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	29.50	18.00	45.00	21.50	4.40	2.30	1.30	1.30	4.00	4.30	(a)	(a)
2	22.50	29.50	32.50	14.50	4.20	3.80	1.20	1.20	3.80	4.00	(a)	(a)
3	11.30	33.00	24.70	11.20	4.80	2.90	1.10	1.60	2.60	3.80	(a)	(a)
4	7.10	23.00	17.70	9.90	4.10	2.50	1.00	1.90	2.20	3.30	(a)	13.40
5	6.30	16.60	15.10	9.80	4.10	2.30	1.00	1.70	1.90	3.20	(a)	10.90
6	5.70	10.90	12.70	9.20	4.00	2.20	1.30	1.60	1.70	3.00	(a)	8.00
7	5.10	8.30	10.70	8.70	3.80	2.10	1.30	2.00	1.60	1.80	(a)	6.00
8	4.80	7.10	9.10	15.40	3.60	2.40	1.40	1.80	1.50	1.70	(a)	4.40
9	4.60	6.20	8.70	13.30	3.90	2.30	1.40	1.70	1.50	1.50	(a)	3.50
10	4.40	5.80	8.00	10.70	4.00	2.10	1.50	1.80	1.40	1.30	(a)	3.10
11	4.25	5.40	7.30	8.90	3.60	2.10	1.40	1.60	1.30	1.50	(a)	2.90
12	4.00	5.10	6.80	8.00	3.30	2.10	2.10	1.70	1.20	1.40	(a)	2.70
13	3.90	5.00	10.30	7.50	3.20	2.00	1.70	1.60	1.50	1.30	(a)	2.60
14	3.65	4.70	11.00	7.10	3.10	1.90	1.60	1.50	1.20	2.00	(a)	2.60
15	3.60	5.65	12.40	7.30	3.30	1.80	1.50	1.40	1.20	2.10	(a)	2.50
16	3.50	6.90	14.20	7.20	6.80	1.70	2.10	1.70	1.10	2.30	(a)	9.60
17	3.50	6.30	30.00	7.20	5.80	1.90	2.50	1.40	1.10	2.10	(a)	25.30
18	3.40	5.60	26.00	9.20	4.70	1.80	2.20	1.20	1.00	1.00	(a)	10.20
19	3.80	5.00	17.70	8.10	5.50	1.70	2.00	1.10	1.00	.90	(a)	12.60
20	4.00	5.10	17.00	7.20	4.40	1.80	2.60	1.00	1.00	.80	2.70	7.70
21	4.50	5.90	14.00	6.50	3.30	1.70	2.20	.90	1.00	.70	2.60	5.50
22	6.00	5.80	12.10	5.90	3.30	1.60	1.60	.90	1.00	2.00	2.20	6.80
23	6.20	5.30	10.50	5.50	3.30	1.70	1.50	.80	.90	1.00	2.00	7.90
24	5.00	4.70	11.10	5.40	3.00	1.60	1.40	.80	1.20	.90	2.10	6.80
25	5.70	5.90	18.50	5.80	2.80	1.50	1.20	.70	1.30	.80	2.10	5.00
26	4.40	6.20	12.50	5.40	2.70	1.40	1.10	.60	1.90	.10	12.90	4.20
27	4.30	6.50	11.00	5.10	2.60	1.30	1.20	.60	1.80	1.60	8.50	3.60
28	5.30	42.00	38.00	4.80	2.60	1.20	1.10	1.10	2.50	(a)	4.30	3.30
29	6.00	.....	43.00	4.70	2.50	1.30	1.30	2.60	3.20	(a)	3.30	3.00
30	7.00	.....	38.50	4.60	2.40	1.30	1.20	7.30	4.00	(a)	2.30	3.50
31	7.90	.....	25.10	.....	2.30	.....	1.40	4.60	.....	(a)	.....	4.50

a No record.

Rating table for Tallapoosa River at Milstead, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*	*Feet.*	*Second-feet.*
0.6	350	4.6	4,825	9.5	10,337	26.0	28,900
.8	562	4.8	5,050	10.0	10,900	27.0	30,025
1.0	774	5.0	5,275	10.5	11,462	28.0	31,150
1.2	990	5.2	5,499	11.0	12,025	29.0	32,275
1.4	1,224	5.4	5,724	11.5	12,587	30.0	33,400
1.6	1,450	5.6	5,949	12.0	13,150	31.0	34,525
1.8	1,675	5.8	6,174	12.5	13,712	32.0	35,650
2.0	1,900	6.0	6,400	13.0	14,275	33.0	36,775
2.2	2,125	6.2	6,624	14.0	15,400	34.0	37,900
2.4	2,350	6.4	6,849	15.0	16,525	35.0	39,025
2.6	2,575	6.6	7,074	16.0	17,650	36.0	40,150
2.8	2,800	6.8	7,299	17.0	18,775	37.0	41,275
3.0	3,025	7.0	7,525	18.0	19,900	38.0	42,400
3.2	3,250	7.2	7,749	19.0	21,025	39.0	43,525
3.4	3,475	7.4	7,974	20.0	22,150	40.0	44,650
3.6	3,700	7.6	8,199	21.0	23,275	41.0	45,775
3.8	3,925	7.8	8,424	22.0	24,400	42.0	46,900
4.0	4.150	8.0	8,650	23.0	25,525	43.0	48,025
4.2	43.75	8.5	9,212	24.0	26,650	44.0	49,150
4.4	4,600	9.0	9,775	25.0	27,775	45.0	50,275

Estimated monthly discharge of Tallapoosa River at Milstead, Ala.

[Drainage area 3,840 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	32,837	3,475	6,951	1.81	2.09
February	46,900	4,937	11,520	3.00	3.12
March	50,275	7,299	20,379	5.31	6.12
April	23,837	4,825	9,234	2.40	2.68
May	7,299	2,237	3,838	1.00	1.15
June	3,925	990	1,835	.48	.54
July	2,575	774	1,368	.36	.42
August	7,861	350	1,529	.40	.46
September	4,150	668	1,621	.42	.47
October 1 to 25			1,843	.48	.45
November 20 to 30			4,252	1.11	.45
December 4 to 31			6,970	1.82	1.93

TALLAPOOSA RIVER AT STURDEVANT, ALA.

This station was established July 19, 1900, by J. R. Hall. It is located at the Columbus and Western Railroad bridge, a fourth of a mile west of Sturdevant. This railroad belongs to the Central of Georgia Railway. The gage rod is 20 feet long, and is graduated to feet and tenths. It is in two sections, and is fastened vertically, the shorter section to a post at the edge of the water on the east bank about 20 feet below the bridge, and the longer section to the first stone pier from the east bank. The initial point of sounding is the east end of the bridge. The section is broken by three piers and by some large rocks below the bridge. The gage is referred to a bench mark consisting of a nail in the southwest corner of pier No. 2, on the east side of the river, 455.70 feet above tide water and 14.20 feet above the zero of the gage. The observer is B. F. Neighbors, farmer and postmaster at Sturdevant, who lives a fourth of a mile from the station. This station, being above the big new dams at Tallassee, is intended to replace Milstead station. Map and profile of Tallapoosa River are published in Twenty-second Annual Report, part 4.

The following discharge measurements were made during 1902:

July 11: Gage height, 1.85 feet; discharge, 1,440 second-feet.
September 17: Gage height, 0.80 foot; discharge, 658 second-feet.
October 9: Gage height, 1.08 feet; discharge, 858 second-feet.
November 12: Gage height, 1.34 feet; discharge, 1,000 second-feet.

Daily gage height, in feet, of Tallapoosa River at Sturdevant, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	11.10	6.90	13.70	8.00	3.50	3.60	1.00	1.10	1.80	2.90	0.9	2.30
2	8.40	11.40	11.00	7.20	3.40	3.10	1.00	1.30	1.50	2.50	.8	3.20
3	6.30	9.10	9.60	5.30	3.40	2.80	.90	1.20	1.30	2.30	.8	7.00
4	4.00	7.00	8.50	5.00	3.30	2.40	.90	1.10	1.90	1.90	.8	5.70
5	3.60	5.60	7.20	4.80	3.30	2.20	.80	2.00	1.60	1.60	1.2	4.50
6	3.40	5.00	6.00	4.70	3.30	2.10	1.40	1.80	1.50	1.40	2.8	4.10
7	3.30	4.80	5.50	4.60	3.20	2.10	1.20	2.50	1.40	1.20	2.7	4.00
8	3.20	4.30	5.00	6.40	3.20	2.00	1.10	2.30	1.20	1.00	2.6	3.90
9	3.10	4.00	4.80	5.20	3.20	2.20	1.20	1.10	1.50	1.90	2.50	3.70
10	3.00	3.80	4.60	5.00	3.20	2.10	1.10	1.10	1.40	1.80	2.30	3.30
11	2.90	3.70	4.50	4.80	3.10	2.00	1.90	1.20	1.10	2.30	2.10	2.90
12	2.90	3.60	4.40	4.50	3.10	1.90	1.60	1.20	1.00	2.00	1.90	2.60
13	2.80	3.50	4.80	4.40	3.10	1.80	1.50	1.40	.90	1.80	1.70	2.30
14	2.80	3.50	4.60	4.30	3.10	1.80	2.00	1.30	.80	1.60	1.50	2.10
15	2.70	4.10	5.90	4.20	4.20	1.70	2.30	1.00	.70	1.50	1.30	2.00
16	2.70	4.50	8.40	4.10	4.00	1.70	2.10	.90	.60	1.40	1.20	7.80
17	2.60	4.00	10.20	4.50	3.50	1.60	1.80	.80	.60	1.30	1.10	8.00
18	2.60	3.80	7.40	5.40	3.40	1.60	2.80	.70	.60	1.20	2.20	5.00
19	2.90	3.60	5.70	4.80	3.30	1.60	2.30	.60	.60	1.20	2.00	4.20
20	2.90	3.50	5.30	4.30	3.10	1.50	1.70	.50	.60	1.20	1.80	4.10
21	3.50	3.50	5.20	4.10	3.00	1.50	1.50	.50	.60	1.1	1.40	4.30
22	4.00	3.50	5.00	4.00	2.90	1.40	1.30	.50	.60	1.1	1.20	4.50
23	3.80	3.40	4.80	3.90	2.80	1.40	1.20	.60	.50	1.1	1.10	3.80
24	3.70	3.40	4.80	3.80	2.70	1.30	1.10	.60	.50	1.0	1.10	3.30
25	3.60	3.70	5.10	3.70	2.60	1.30	1.00	.50	.80	1.0	3.80	3.00

Daily gage height, in feet, of Tallapoosa River at Sturdevant, Ala.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
26	3.50	3.80	4.90	3.70	2.50	1.30	.90	.40	.80	1.0	5.20	2.80
27	3.40	3.90	6.80	3.70	2.40	1.20	.90	1.20	3.00	1.0	5.00	2.60
28	4.00	16.10	16.10	3.60	2.40	1.20	.80	2.40	4.10	1.0	4.30	2.50
29	4.50	.....	11.60	3.60	2.30	1.20	.90	6.00	3.20	.9	2.80	2.40
30	5.00	.....	10.90	3.50	2.30	1.10	1.00	3.40	4.10	.9	2.30	2.60
31	5.00	.....	9.20	.....	2.20	.....	1.00	2.30	.....	.9	.....	3.90

Estimated monthly discharge of Tallapoosa River at Sturdevant, Ala.

[Drainage area, 2,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	15,695	2,520	4,550	1.82	2.10
February	23,245	3,760	6,288	2.52	2.62
March	23,245	5,310	9,708	3.88	4.47
April	10,890	3,914	5,677	2.27	2.53
May	5,000	1,910	3,240	1.30	1.50
June	4,070	840	1,544	.62	.69
July	2,830	660	1,004	.40	.46
August	7,790	470	1,298	.52	.60
September	4,845	510	1,255	.50	.56
October	2,985	715	1,180	.47	.54
November	6,550	660	2,011	.80	.89
December	10,890	1,640	4,412	1.76	2.03
The year	23,245	470	3,514	1.40	18.99

Rating table for Tallapoosa River at Sturdevant, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	555	3.0	3,140	5.4	6,860	10.5	14,765
.8	660	3.2	3,450	5.6	7,170	11.0	15,540
1.0	775	3.4	3,760	5.8	7,480	11.5	16,315
1.2	910	3.6	4,070	6.0	7,790	12.0	17,090
1.4	1,055	3.8	4,380	6.5	8,565	12.5	17,865
1.6	1,220	4.0	4,690	7.0	9,340	13.0	18,640
1.8	1,410	4.2	5,000	7.5	10,115	13.5	19,415
2.0	1,640	4.4	5,310	8.0	10,890	14.0	20,190
2.2	1,910	4.6	5,620	8.5	11,665	14.5	20,965
2.4	2,210	4.8	5,930	9.0	12,440	15.0	21,740
2.6	2,520	5.0	6,240	10.0	13,215		
2.8	2,830	5.2	6,550	9.5	13,990		

Estimated monthly discharge of Tallapoosa River at Sturdevant, Ala.

[Drainage area, 2,500 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1900.					
July 19–31			4,002	1.60	0.77
August	5,155	1,520	2,533	1.01	1.16
September	17,090	1,220	3,602	1.44	1.61
October	9,805	1,220	3,398	1.36	1.57
November	7,635	1,910	3,275	1.31	1.46
December	10,115	2,520	4,330	1.73	1.99
1901.					
January	20,345	4,690	7,035	2.81	3.24
February	18,485	4,535	6,468	2.59	2.70
March	12,285	3,450	5,315	2.13	2.46
April	12,440	4,535	6,772	2.61	2.91
May	10,270	3,140	4,885	1.95	2.25
June	7,170	2,365	4,452	1.78	1.99
July	5,155	1,640	2,795	1.12	1.29
August	16,625	1,640	4,793	1.92	2.21
September	9,340	1,640	2,852	1.14	1.27
October	7,790	1,220	1,946	.78	.90
November	2,055	1,220	1,502	.70	.78
December	24,150	1,310	4,670	1.87	2.16
The year	24,150	1,220	4,457	1.78	24.16

HILLABEE CREEK NEAR ALEXANDER, ALA.

This station, which was established August 29, 1900, by J. R. Hall, is located 6½ miles northeast of Alexander, on the road leading from that town to Newsite. The gage is graduated to feet and tenths, is placed vertically, and is in two sections. The short section, which reads from 0 to 5.50 feet, is fastened to a post in the edge of the water on the north bank, 20 feet from the upstream side of the bridge. The long section, which reads from 5.50 to 16 feet, is fastened to the upstream end of the first pier on the north bank. Both sections can be easily read from the north approach to the bridge. The initial point of sounding is on the south side of the first pier on the north bank. The gage is referred to a bench mark at the top of a chord on the downstream side of the bridge at the second pier from the north

bank, and is 27.6 feet above the zero of the gage. The bridge is in three spans, having a total length of 276 feet, with a north approach of 116 feet and a south approach of 124 feet, making a total, over all, of 516 feet. The observer is J. H. Chisolm, a farmer, whose post-office address is Alexander, Ala.

The following discharge measurement was made in 1902:

July 16: Gage height, 1.12 feet; discharge, 169 second-feet.

Daily gage height, in feet, of Hillabee Creek near Alexander, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.70	5.30	4.10	3.40	1.90	1.60	0.80	0.80	1.40	3.20	0.90	1.80
2	3.50	7.70	4.00	3.20	1.90	1.60	.80	.80	3.60	3.20	.80	6.00
3	3.00	3.70	3.90	3.00	1.80	1.70	.80	.90	1.90	3.00	.70	4.20
4	2.00	3.00	2.90	3.00	1.80	1.70	.80	1.20	1.50	3.00	2.60	3.50
5	2.00	2.70	3.00	3.00	1.90	1.70	.70	1.10	1.40	3.00	3.60	2.00
6	2.00	2.50	3.50	2.90	1.90	1.60	.70	1.10	1.30	2.80	2.60	1.90
7	2.00	2.40	3.60	4.10	1.90	1.60	.70	1.00	1.20	2.60	1.10	1.90
8	1.90	2.10	2.60	3.40	1.90	1.60	.70	1.00	1.10	2.60	1.00	1.90
9	1.80	2.10	2.40	3.20	1.80	1.60	.80	.90	1.40	3.30	1.00	1.80
10	1.70	2.00	2.30	2.80	1.80	1.50	1.00	.90	1.30	4.10	1.00	1.80
11	1.70	2.00	2.30	2.60	1.80	1.50	1.10	.90	1.20	3.80	1.00	1.70
12	1.70	2.00	2.00	2.60	1.70	1.40	1.30	.90	1.10	2.10	1.00	1.60
13	1.70	1.90	2.50	2.60	1.70	1.40	1.30	.80	1.10	2.40	.90	1.60
14	1.60	1.90	3.00	2.50	1.70	1.40	1.30	.80	1.00	2.60	.90	1.60
15	1.60	2.00	3.70	2.40	1.60	1.40	1.20	.80	1.00	2.30	.80	6.00
16	1.60	2.20	8.00	2.40	1.60	1.40	1.20	.80	1.00	2.20	.80	4.00
17	1.60	2.10	3.90	2.40	1.80	1.40	1.10	1.00	1.00	2.00	1.00	2.60
18	1.60	2.10	3.40	2.40	2.00	1.30	.90	.90	1.00	1.60	1.00	2.00
19	2.00	2.00	3.10	2.30	1.90	1.30	.90	.70	1.00	1.40	.90	1.90
20	1.90	2.00	3.00	2.40	1.90	1.20	.90	.70	.90	2.60	.90	1.90
21	2.80	2.10	3.90	2.30	1.80	1.20	.80	.70	.80	2.40	.90	1.90
22	2.10	2.00	3.50	2.20	1.80	1.20	.80	.70	.80	2.00	.80	1.80
23	2.00	2.00	4.00	2.20	1.80	1.20	.80	.70	.80	1.60	.70	2.00
24	2.00	2.00	3.40	2.10	1.70	1.10	.70	.70	.80	1.40	.70	2.00
25	1.90	2.20	3.00	2.10	1.70	1.10	.70	.70	2.10	1.10	1.30	1.90
26	1.90	2.00	3.00	2.00	1.70	1.00	.80	.70	2.00	1.00	1.40	1.80
27	1.90	7.00	7.00	2.00	1.70	.90	.80	2.00	1.80	.90	1.40	1.80
28	2.90	12.50	14.00	2.00	1.60	.90	.80	1.70	1.80	.90	1.50	3.50
29	3.00	.....	8.00	2.00	1.60	.80	.70	3.60	2.10	.90	1.60	2.20
30	2.70	.....	4.10	2.00	1.60	.90	.70	1.90	3.40	.90	1.70	2.00
31	2.80	.....	3.90	.....	1.60	.....	70	1.50	.....	1.00	.....	1.90

Rating table for Hillabee Creek near Alexander, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	125	2.2	478	3.6	1,094	5.0	1,710
1.0	138	2.4	566	3.8	1,182	6.0	2,150
1.2	156	2.6	654	4.0	1,270	7.0	2,590
1.4	184	2.8	742	4.2	1,358	8.0	3,030
1.6	230	3.0	830	4.4	1,446	9.0	3,470
1.8	303	3.2	918	4.6	1,534	10.0	3,910
2.0	390	3.4	1,006	4.8	1,622	11.0	4,350

Estimated monthly discharge of Hillabee Creek near Alexander, Ala.

[Drainage area, 214 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	1,138	230	459	2.14	2.47
February	5,010	346	854	3.99	4.15
March	5,670	390	1,284	6.00	6.92
April	1,314	390	647	3.02	3.37
May	390	230	294	1.37	1.58
June	263	125	186	.87	.97
July	169	120	137	.64	.74
August	1,094	120	182	.85	.98
September	1,094	125	254	1.19	1.33
October	1,314	131	525	2.45	2.82
November	1,094	120	213	1.00	1.12
December	2,150	230	569	2.66	3.07
The year	5,670	120	467	2.18	29.52

TALLADEGA CREEK AT NOTTINGHAM, ALA.

This station is located on the Southern Railway bridge, a fourth of a mile from the depot at Nottingham, Ala., and 1 mile north of Alpine, Ala. The gage, which is graduated to feet and tenths and is 20 feet long, is fastened vertically to a tree on the right bank, about 50 feet upstream from the bridge. The initial point of sounding is end of iron bridge, upstream, right bank. The bench mark is the top rail on the upstream side of the bridge, and is 24.13 feet above gage datum. The section is a good one, and is free from piers. The observer is R. M. McClatchy, station agent at Nottingham.

The following discharge measurements were made during 1902:

January 16: Gage height, 1.30 feet; discharge, 1.55 second-feet.
July 17: Gage height, 0.90 foot; discharge, 97 second-feet.
October 18: Gage height, 0.80 foot; discharge, 78 second-feet.
November 13: Gage height, 0.70 foot; discharge, 63 second-feet.

Daily gage height, in feet, of Talladega Creek at Nottingham, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.40	5.60	5.00	3.50	1.80	2.60	0.90	0.90	1.00	1.40	0.70	0.80
2	2.20	8.90	3.70	3.10	1.70	1.50	.90	.80	.90	1.10	.70	2.40
3	2.00	4.40	3.10	2.90	1.60	1.30	.90	.80	.70	.90	.70	2.70
4	1.80	3.30	2.90	2.90	1.50	1.30	.90	.80	.70	.80	.70	1.60
5	1.70	2.70	4.60	2.70	1.50	1.20	1.00	.80	.70	.70	.70	1.40
6	1.60	2.50	3.30	2.50	1.50	1.10	1.00	.80	.70	.70	1.90	1.20
7	1.50	2.30	2.90	3.60	1.60	1.10	1.00	.80	.70	.70	1.10	1.30
8	1.50	2.10	2.60	3.20	1.90	1.10	.90	.80	.70	.70	.90	1.20
9	1.50	2.10	2.50	3.00	1.70	1.10	1.00	.80	.70	.70	.80	1.10
10	1.50	2.00	2.40	2.70	1.60	1.10	1.50	1.00	.70	.70	.80	1.00
11	1.40	1.90	2.30	2.50	1.60	1.10	2.00	1.20	.70	4.10	.70	.90
12	1.40	1.90	2.20	2.30	1.50	1.10	1.50	1.50	.70	1.90	.70	.80
13	1.30	1.90	2.20	2.30	1.40	1.10	1.20	1.10	.70	1.30	.70	.80
14	1.30	1.90	2.10	2.30	1.40	1.10	1.00	1.00	.70	1.00	.70	.80
15	1.30	2.30	2.60	2.20	1.40	1.10	1.00	.90	.70	.80	.70	.80
16	1.30	2.10	7.60	2.10	1.40	1.10	1.00	.80	.70	.80	.70	6.30
17	1.30	1.90	3.80	2.50	1.50	1.10	.90	.80	.70	.80	.70	2.50
18	1.30	1.80	2.70	2.30	1.60	1.00	.90	.80	.70	.70	1.20	1.80
19	1.40	1.80	2.60	2.20	1.50	1.00	.90	.80	.70	.80	1.00	1.40
20	1.90	1.90	2.40	2.10	1.40	1.00	.90	.80	.70	.80	.90	1.20
21	2.10	1.80	2.40	2.00	1.30	1.00	1.50	.80	.60	.80	.80	2.30
22	1.70	2.00	2.30	1.90	1.30	1.10	1.10	.70	.60	.80	.80	2.60
23	1.60	1.90	2.20	1.90	1.30	1.10	1.00	.70	.60	.80	.80	2.20
24	1.50	1.80	3.20	1.90	1.30	.90	1.00	.70	.60	.80	.80	1.50
25	1.80	1.90	3.20	1.80	1.20	.90	1.00	.70	.70	.80	1.90	1.30
26	1.60	1.80	2.50	1.80	1.20	.90	1.00	.70	.70	.80	1.40	1.10
27	1.80	3.60	2.50	1.80	1.20	.90	1.00	.70	.60	.80	1.10	1.10
28	3.30	12.20	12.50	1.80	1.10	.90	1.00	1.50	1.10	.80	.90	1.10
29	4.10	.....	10.70	1.80	1.10	.90	1.00	5.10	1.10	.70	.80	1.30
30	2.80	.....	5.20	1.80	1.10	.90	1.00	3.10	1.70	.70	.70	2.40
31	3.50	.....	3.90	.....	1.10	.....	1.00	1.00	.....	.70	.....	1.80

Rating table for Talladega Creek at Nottingham, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	51	2.8	482	5.0	966	7.2	1,450
.8	78	3.0	526	5.2	1,010	7.4	1,494
1.0	109	3.2	570	5.4	1,054	7.6	1,538
1.2	143	3.4	614	5.6	1,098	7.8	1,582
1.4	179	3.6	658	5.8	1,142	8.0	1,626
1.6	219	3.8	702	6.0	1,186	8.5	1,736
1.8	262	4.0	746	6.2	1,230	9.0	1,846
2.0	306	4.2	790	6.4	1,274	9.5	1,956
2.2	350	4.4	834	6.6	1,318	10.0	2,066
2.4	394	4.6	878	6.8	1,362	10.5	2,176
2.6	438	4.8	922	7.0	1,406	11.0	2,286

Estimated monthly discharge of Talladega Creek at Nottingham, Ala.

[Drainage area, 156 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	768	161	276	1.77	2.04
February	2,550	262	513	3.29	3.43
March	2,616	328	676	4.33	4.99
April	658	262	390	2.50	2.79
May	284	126	187	1.20	1.38
June	438	93	128	.82	.91
July	306	93	121	.78	.90
August	988	64	135	.87	1.00
September	240	51	74	.47	.52
October	768	64	111	.71	.82
November	284	64	97	.62	.69
December	1,252	78	238	1.53	1.76
The year	2,616	51	246	1.57	21.23

COOSA RIVER AT RIVERSIDE, ALA.

This station, described in the Eighteenth Annual Report, part 4, page 99, was established September 25, 1896, at the bridge of the Southern Railway across the Coosa River, at Riverside, Ala. The

town of Riverside is on the west bank of the river, and the railroad station is 1,000 feet west of the bridge at which the measurements are made. The length of the gage chain from the bottom of the weight to the index is 34.50 feet. The bench mark is the top capstone on the large circular center pier of the turn span, the elevation of which is 26.80 feet above gage datum. The channel is straight, the current swift, but somewhat obstructed by a ledge of rock under water about 300 feet above the station. The observer is J. W. Foster, Riverside, Ala. The initial point is the top of the left abutment at the edge toward the river, on the downstream side of the bridge.

During 1902 the following discharge measurements were made:

April 8: Gage height, 7.30 feet; discharge, 21,138 second-feet.
June 3: Gage height, 2 feet; discharge, 4,720 second-feet.
October 17: Gage height, 2.30 feet; discharge, 5,128 second-feet.

Daily gage height, in feet, of Coosa River at Riverside, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	15.70	10.40	15.00	15.50	3.35	2.15	1.60	1.40	2.40	2.50	1.20	2.80
2	13.30	13.35	15.40	14.80	3.25	2.10	1.50	1.60	2.00	2.25	1.20	2.40
3	15.10	14.60	15.20	14.60	3.20	2.05	1.50	2.00	1.50	2.00	1.20	4.50
4	15.30	14.40	14.90	14.40	3.30	2.00	1.45	1.60	1.40	1.90	1.15	6.00
5	15.10	14.00	15.60	12.70	3.40	2.00	1.45	1.40	2.00	1.80	1.20	7.20
6	14.50	13.40	15.00	8.90	3.20	1.90	1.40	1.45	1.80	1.75	1.60	6.80
7	13.10	13.20	14.90	6.40	3.10	1.90	1.40	1.90	1.40	1.70	1.80	5.40
8	9.30	11.25	14.10	7.20	3.00	1.85	1.40	1.85	1.50	2.00	1.90	4.80
9	6.20	9.10	13.00	7.60	2.90	1.80	1.35	1.80	1.50	1.75	1.85	4.20
10	4.80	6.00	9.90	7.70	2.75	1.80	1.35	1.80	1.40	1.60	1.70	3.90
11	4.60	5.20	8.10	7.00	2.70	1.80	1.40	2.00	1.40	2.40	1.60	3.50
12	2.90	5.00	6.90	6.20	2.65	2.20	1.40	1.80	1.45	4.00	1.50	2.90
13	2.85	4.90	6.65	5.70	2.75	2.20	1.45	1.70	1.40	3.80	1.30	2.40
14	4.50	4.50	6.40	5.30	2.80	1.95	1.45	1.60	1.40	3.25	1.25	2.45
15	5.25	5.00	6.20	4.85	2.85	1.85	1.50	1.60	1.30	2.65	1.20	2.50
16	7.20	5.80	7.20	4.70	2.65	1.80	1.60	1.35	1.25	2.50	1.20	3.60
17	6.70	5.20	9.00	4.60	2.60	1.80	2.25	1.25	2.00	2.40	1.15	5.30
18	6.20	5.00	9.90	4.90	3.30	1.85	2.85	1.20	1.65	2.10	1.20	5.60
19	2.90	4.90	10.20	4.95	2.90	2.20	2.80	1.20	1.50	1.90	1.25	5.40
20	2.85	4.85	9.40	5.35	2.60	2.00	2.20	1.20	1.20	1.75	1.40	4.90
21	4.50	4.60	8.20	5.00	2.50	1.95	1.95	1.25	1.10	1.60	1.60	5.00
22	5.25	4.90	6.90	4.90	2.45	1.90	1.90	1.25	1.15	1.65	2.00	6.90
23	7.20	4.90	5.90	4.50	2.40	1.90	1.80	1.40	1.25	1.45	1.80	7.80
24	6.70	5.00	5.40	4.30	2.40	1.85	1.75	1.60	1.25	1.35	1.40	7.40
25	6.20	5.35	5.45	3.90	2.35	1.85	1.45	1.70	1.20	1.30	1.60	6.35
26	5.20	5.75	5.30	3.70	2.30	2.00	1.40	1.70	1.35	1.30	2.20	5.10
27	4.50	6.35	6.20	3.70	2.25	1.90	1.50	1.65	2.00	1.30	2.90	4.50
28	5.10	12.50	8.90	3.60	2.25	1.85	2.30	1.65	4.00	1.25	3.45	3.50
29	6.50	.....	13.30	3.50	2.20	1.80	1.60	1.60	3.50	1.25	3.90	3.40
30	7.00	.....	17.30	3.40	2.20	1.75	1.50	2.20	3.40	1.25	3.50	3.35
31	7.40	.....	16.50	.....	2.20	.....	1.40	2.40	.....	1.20	.....	3.25

Rating table for Coosa River at Riverside, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	2,470	4.0	10,300	7.0	21,100	13.0	45,100
1.2	2,760	4.2	11,000	7.2	21,900	13.5	47,100
1.4	3,100	4.4	11,700	7.4	22,700	14.0	49,100
1.6	3,500	4.6	12,400	7.6	23,500	14.5	51,100
1.8	3,940	4.8	13,100	7.8	24,300	15.0	53,100
2.0	4,400	5.0	13,800	8.0	25,100	15.5	55,100
2.2	4,900	5.2	14,500	8.5	27,100	16.0	57,100
2.4	5,430	5.4	15,200	9.0	29,100	16.5	59,100
2.6	5,970	5.6	15,900	9.5	31,100	17.0	61,100
2.8	6,530	5.8	16,600	10.0	33,100	17.5	63,100
3.0	7,100	6.0	17,300	10.5	35,100	18.0	65,100
3.2	7,700	6.2	18,060	11.0	37,100	18.5	67,100
3.4	8,330	6.4	18,820	11.5	39,100	19.0	69,100
3.6	8,970	6.6	19,580	12.0	41,100		
3.8	9,620	6.8	20,340	12.5	43,100		

Estimated monthly discharge of Coosa River at Riverside, Ala.

[Drainage area 7,065 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	55,900	6,670	23,804	3.37	3.89
February	51,500	12,050	24,839	3.52	3.67
March	62,300	14,850	34,762	4.92	5.67
April	55,100	8,330	20,872	2.95	3.29
May	8,330	4,900	6,375	.90	1.04
June	4,900	3,830	4,247	.60	.67
July	6,670	3,015	3,718	.53	.61
August	5,430	2,760	3,577	.51	.59
September	10,300	2,610	3,938	.56	.62
October	10,300	2,760	4,576	.65	.75
November	9,950	2,685	3,994	.57	.64
December	24,300	5,430	12,719	1.80	2.08
The year	62,300	2,610	12,285	1.74	23.52

COOSA RIVER AT ROME, GA.

Coosa River is formed by the junction of Etowah and Oostanaula rivers at Rome, Ga. Both the tributary rivers rise in the northern part of Georgia and flow for the most part through a hilly, broken country, well wooded, about one-fourth of the land being under cultivation. The measurements at Rome are made on the Oostanaula and the Etowah just above their junction. The Etowah is measured at the Second avenue bridge and the Oostanaula at the Fifth avenue bridge in Rome, and the results are added to give the flow of the Coosa. The gage height is taken from the United States Weather Bureau gage at the Fifth avenue bridge, on the Oostanaula. There is practically no fall on Oostanaula River from the Fifth avenue bridge to the junction; hence the gage is used as a Coosa River gage, and gives the fluctuations of Coosa River. This gage is a 4 by 6 inch timber, graduated to feet and tenths, and fastened to the downstream left-hand corner of the first pier from the left bank. The zero of the gage is 575.79 feet above sea level. The United States Weather Bureau has maintained the station here for many years. It is now maintained only as a half-year station, from November 1 to April 30, inclusive; but W. M. Towers, the river observer, kindly reads the gage and furnishes the Geological Survey with monthly reports of the daily gage heights for the entire year without charge. The channel of the Etowah is straight and the current swift and unobstructed; but the Oostanaula is rather sluggish and somewhat obstructed by piers. The banks are high, but liable to overflow at times of high water.

The following discharge measurements were made during 1902:

June 24: Gage height, 1.30 feet; discharge, 2,483 second-feet.
October 8: Gage height, 0.80 feet; discharge, 1,800 second-feet.
November 8: Gage height, 1.10 feet; discharge, 2,332 second-feet.

Daily gage height, in feet, of Coosa River at Rome, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	28.00	11.80	28.50	21.30	2.90	1.80	1.00	1.20	1.00	1.60	0.20	1.90
2	24.60	22.00	27.60	14.80	2.90	1.70	1.00	1.00	.80	1.60	.20	2.00
3	21.90	24.00	24.10	7.20	3.70	1.70	1.10	.80	1.20	1.60	.20	6.20
4	17.60	20.00	21.60	5.80	3.40	1.70	1.00	.80	1.00	1.50	.20	6.80
5	6.60	15.60	19.20	5.70	3.20	1.70	.90	1.50	1.20	1.00	.20	5.80
6	5.60	9.80	14.00	5.20	3.00	1.70	.90	1.40	1.00	2.00	.40	5.00
7	4.60	6.30	10.10	6.70	2.90	1.70	1.00	1.20	.80	1.40	2.00	4.00
8	4.20	5.70	8.70	6.70	2.80	1.70	.90	1.20	.60	.90	1.60	2.70
9	4.00	5.00	7.20	7.70	2.60	2.00	.90	.60	.90	.80	1.00	2.50
10	3.90	4.60	7.00	6.60	2.60	1.90	.90	.40	1.00	.70	.80	1.90
11	3.60	4.40	6.60	5.60	2.50	1.90	.90	.30	.90	2.30	.80	1.60
12	3.50	4.00	6.00	5.00	2.40	1.80	1.40	.30	.70	2.20	.70	1.40
13	3.40	3.90	5.60	4.70	2.30	1.70	1.50	1.00	.60	2.20	.60	1.20
14	3.20	3.80	5.50	4.50	2.30	1.70	1.80	.60	2.50	2.00	.60	1.20

Daily gage height, in feet, of Coosa River at Rome, Ga.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
15	3.00	3.80	5.00	4.40	2.30	1.60	1.40	.60	1.90	1.80	.60	1.10
16	2.80	4.00	7.00	4.30	2.40	1.60	2.00	.80	1.00	1.60	.60	2.40
17	2.70	4.50	14.00	4.50	2.50	1.60	1.40	.60	.70	1.50	.60	4.30
18	2.70	4.70	11.60	5.70	2.30	1.50	1.20	.50	.40	1.30	.90	4.50
19	3.00	4.50	8.60	5.00	2.30	1.50	1.00	.40	.40	1.10	1.50	3.80
20	3.20	4.00	6.20	4.00	2.40	1.90	1.00	1.00	.40	.90	1.30	3.00
21	3.60	4.00	5.60	3.90	2.40	1.60	.90	1.30	1.00	.80	1.10	4.90
22	4.20	5.00	5.10	3.80	2.30	1.80	.80	1.00	.80	.70	1.10	5.80
23	5.00	5.60	5.00	3.70	2.30	1.50	.80	.90	.60	.60	1.00	5.80
24	4.00	5.30	4.70	3.50	2.10	1.30	.70	.70	.30	.50	.90	5.20
25	3.90	5.00	4.70	3.30	2.00	1.30	.60	.50	2.20	.40	1.60	3.80
26	3.60	5.50	4.60	3.20	2.00	1.20	.50	.50	4.00	.30	3.10	3.00
27	3.60	5.50	4.20	3.20	2.00	1.20	.50	.60	3.30	.20	4.80	2.60
28	4.20	22.70	5.00	3.00	1.80	1.10	.50	1.20	2.00	.40	3.80	2.20
29	6.50	.....	20.60	3.00	1.80	1.00	.70	1.70	2.00	.40	2.40	2.20
30	5.80	.....	28.90	2.90	1.80	1.00	2.00	1.00	1.80	.30	2.20	2.60
31	5.40	.....	26.80	.....	1.80	.....	1.60	1.00	.....	.30	.....	4.00

Rating table for Coosa River at Rome, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	1,410	4.2	7,102	8.2	15,142	15.5	29,815
0.4	1,555	4.4	7,504	8.4	15,544	16.0	30,820
0.6	1,720	4.6	7,906	8.6	15,946	17.0	32,830
0.8	1,905	4.8	8,308	8.8	16,348	18.0	34,840
1.0	2,110	5.0	8,710	9.0	16,750	19.0	36,850
1.2	2,350	5.2	9,112	9.2	17,152	20.0	38,860
1.4	2,600	5.4	9,514	9.4	17,554	21.0	40,870
1.6	2,850	5.6	9,916	9.6	17,956	22.0	42,880
1.8	3,120	5.8	10,318	9.8	18,358	23.0	44,890
2.0	3,400	6.0	10,720	10.0	18,760	24.0	46,900
2.2	3,700	6.2	11,122	10.5	19,765	25.0	48,910
2.4	4,000	6.4	11,524	11.0	20,770	26.0	50,920
2.6	4,300	6.6	11,926	11.5	21,775	27.0	52,930
2.8	4,600	6.8	12,328	12.0	22,780	28.0	54,940
3.0	4,900	7.0	12,730	12.5	23,785	29.0	56,950
3.2	5,230	7.2	13,132	13.0	24,790	30.0	58,960
3.4	5,580	7.4	13,534	13.5	25,795	31.0	60,970
3.6	5,930	7.6	13,936	14.0	26,800	32.0	62,980
3.8	6,300	7.8	14,338	14.5	27,805	33.0	64,990
4.0	6,700	8.0	14,740	15.0	28,810	34.0	67,000

Estimated monthly discharge of Coosa River at Rome, Ga.

[Drainage area, 4,006 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	54,940	4,450	11,816	2.95	3.40
February	46,900	6,300	14,812	3.70	3.85
March	56,749	7,102	21,944	5.48	6.32
April	41,473	4,750	10,015	2.50	2.79
May	6,115	3,120	4,089	1.02	1.18
June	3,400	2,110	2,836	.71	.79
July	3,400	1,635	2,214	.55	.63
August	2,985	1,480	1,998	.50	.58
September	6,700	1,480	2,505	.63	.70
October	3,850	1,410	2,346	.59	.68
November	8,308	1,410	2,572	.64	.71
December	12,328	2,225	5,885	1.47	1.69
The year	56,749	1,410	6,920	1.73	23.32

ETOWAH RIVER AT CANTON, GA.

This station is one-half mile above the mouth of Canton Creek, and is located at the iron highway bridge over Etowah River, about 1,000 feet north of and upstream from the Atlanta, Knoxville and Northern Railroad depot at Canton, Ga. The United States Weather Bureau gage rod is used. The observer is J. A. Low. The bench mark is on the left-bank pier. The iron bridge rests on four pieces of railroad track iron, forming a cap. Measuring from the end toward the river on one of these on the upstream side of the bridge, its top is 23.3 feet above the datum of the gage. Up to 3 feet gage height the river is only 116 feet wide, and flows between the piers on its lower banks. Up to about 14 feet it is confined between its upper banks, which are the abutments at the outer ends of the approaches. Above this stage it begins to overflow the bottom lands. The initial point is the top of the right-bank pier, at its edge toward the river.

During the year 1902 a fish-trap dam about 1 foot high was constructed across the river about 400 yards below the gage, which changed the rating to such an extent that two different rating tables had to be constructed for the year. To overcome this trouble a gage will be placed below the fish trap.

Discharge measurements of Etowah River at Canton, Ga.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 29	Max Hall	15.10	12,058
April 26	Olin P. Hall	.90	1,199
July 12	Max Hall	.51	779
August 16	Olin P. Hall	.20	419
November 22	do	.44	410

Daily gage height, in feet, of Etowah River at Canton, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.70	5.60	10.80	2.80	0.50	0.40	0.40	0.50	0.80	2.80	0.60	2.70
2	3.30	11.80	4.30	2.40	1.00	.60	.40	.50	.80	1.80	.50	4.00
3	3.00	5.40	3.10	2.10	1.10	.60	.30	.50	1.20	.80	.50	4.20
4	2.90	3.10	3.00	1.80	1.00	.30	.40	.50	1.20	.80	.50	2.10
5	2.80	2.70	2.80	1.60	.90	.30	.40	.40	1.40	.80	.50	2.80
6	2.50	2.30	2.80	1.50	.80	.30	.40	.40	1.40	.60	.80	1.80
7	2.20	2.20	2.50	1.40	.70	.30	.40	.40	1.00	.60	.70	1.20
8	2.00	2.10	2.10	1.40	.70	1.30	.40	.40	1.00	.60	.70	1.10
9	1.90	2.00	1.90	1.30	.60	2.00	.40	.40	1.00	.80	.60	1.10
10	1.70	1.80	1.80	1.30	.50	1.80	.40	1.00	1.00	.80	.70	1.00
11	1.60	1.60	1.70	1.30	.60	1.00	.30	1.00	1.00	.70	.70	.90
12	1.60	1.50	1.70	1.20	.50	1.00	.40	1.20	.80	.70	.80	.90
13	1.50	1.30	1.60	1.10	.60	1.00	.30	1.00	.80	.70	.80	.80
14	1.50	1.20	1.50	1.00	.60	1.00	.30	.80	.80	.70	.80	.80
15	1.40	1.20	1.40	1.00	.50	1.00	.40	.80	.80	.50	.80	.80
16	1.40	1.10	1.80	1.00	.50	1.00	.40	.20	1.80	.50	.90	1.70
17	1.40	1.00	3.10	1.00	.50	2.40	.40	.80	1.00	.50	.90	1.60
18	1.40	1.20	2.40	2.40	.50	2.00	.60	.80	1.00	.70	.90	1.60
19	1.50	1.20	1.70	1.70	.40	1.00	.60	.60	1.00	.90	1.00	1.50
20	1.70	1.00	1.60	1.30	.50	1.00	.70	.60	.80	.90	.90	1.50
21	1.70	.90	1.60	1.00	.50	1.00	.60	.60	.80	.80	.80	1.50
22	1.70	.70	1.50	.80	.40	.80	.60	.60	.80	.80	.40	1.50
23	1.60	.70	1.50	.70	.40	.80	.50	.60	.60	.80	.70	1.50
24	1.90	.60	1.50	.70	.40	.60	.80	.60	3.00	.80	.60	1.40
25	2.00	.50	1.50	.60	.40	.50	.80	.60	1.00	.80	2.10	1.40
26	1.90	.50	1.40	.90	.40	.50	.80	.40	1.00	.80	4.30	3.50
27	2.00	.50	1.40	.60	.50	.50	.70	.40	1.00	.80	3.10	3.60
28	3.00	18.80	2.50	.60	.30	.40	.80	.40	.80	.80	2.50	3.60
29	3.80	.....	16.00	.60	.30	.40	.80	.40	.80	.80	2.10	3.00
30	3.60	.....	5.40	.60	.30	.40	.80	.80	.80	.80	2.20	3.00
31	3.40	.....	3.20	.....	.30	.....	.60	.80	.....	.80	.....	3.00

Rating table for Etowah River at Canton, Ga., for 1902.

[From January 1 to July 31.]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	820	2.6	2,648	7.5	6,715	13.0	11,280
.6	988	2.8	2,814	8.0	7,130	13.5	11,695
.8	1,154	3.0	2,980	8.5	7,545	14.0	12,110
1.0	1,320	3.5	3,395	9.0	7,960	14.5	12,525
1.2	1,486	4.0	3,810	9.5	8,375	15.0	12,940
1.4	1,652	4.5	4,225	10.0	8,790	15.5	13,355
1.6	1,818	5.0	4,640	10.5	9,205	16.0	13,770
1.8	1,984	5.5	5,055	11.0	9,620	16.5	14,185
2.0	2,150	6.0	5,470	11.5	10,035	17.0	14,600
2.2	2,316	6.5	5,885	12.0	10,450	17.5	15,015
2.4	2,482	7.0	6,300	12.5	10,865	18.0	15,430

[From August 1 to December 31.]

0.2	350	1.2	1,040	2.2	1,940	3.2	2,840
.4	420	1.4	1,220	2.4	2,120	3.4	3,020
.6	530	1.6	1,400	2.6	2,300	3.6	3,200
.8	680	1.8	1,580	2.8	2,480	3.8	3,380
1.0	860	2.0	1,760	3.0	2,660	4.0	3,560

Estimated monthly discharge of Etowah River at Canton, Ga.

[Drainage area, 604 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	3,644	1,652	2,300	3.81	4.39
February	16,094	905	2,698	4.47	4.65
March	13,770	1,652	2,929	4.85	5.59
April	2,814	988	1,533	2.54	2.83
May	1,403	740	950	1.57	1.81
June	2,482	740	1,215	2.01	2.24
July	1,154	740	920	1.52	1.75
August	1,040	350	562	.93	1.07
September	2,660	530	897	1.49	1.66
October	2,480	470	725	1.20	1.38
November	3,830	420	978	1.62	1.81
December	3,740	680	1,737	2.88	3.32
The year	16,094	350	1,454	2.41	32.50

COOSAWATTEE RIVER AT CARTERS, GA.

This river is formed by the junction of Ellijay and Cartecay rivers at Ellijay, Ga., and flows in a southwesterly direction, joining the Conasauga to form the Oostanaula. Its drainage area is for the most part mountainous and covered with forest growth. The station was established August 15, 1896, at the iron highway bridge at Carters, Murray County, Ga., about 20 miles northeast of Calhoun, the most convenient railroad station. Carters is at the head of navigation, small boats running to Rome, Ga., and the Coosa River below. It is at the foot of the great shoals made by this stream in cutting through the Cohutta Mountains, the last of which is Carters Shoals, a short distance above the bridge, with a fall of 50 feet.

The length of the wire gage is 37.24 feet. The top of the cylindrical iron pier at the right-bank downstream corner of the bridge is 30.35 feet above gage datum. The current is swift, but is broken by a gravel bar above the section. The bed is gravelly and not apt to change. The banks are high, but occasionally overflow at high water. The observer is H. S. Weems, a merchant at Carters, Ga.

The following discharge measurements were made during 1902:

April 28: Gage height, 2.72 feet; discharge, 1,088 second-feet.
August 8: Gage height, 0.95 feet; discharge, 313 second-feet.
November 4: Gage height, 0.85 feet; discharge, 273 second-feet.
December 30: Gage height, 2.30 feet; discharge, 902 second-feet.

Daily gage height, in feet, of Coosawattee River at Carters, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	9.00	11.00	15.00	4.00	3.00	1.70	1.70	0.90	0.90	1.00	0.70	2.50
2	7.00	9.00	15.00	3.90	3.00	1.70	1.70	.80	.80	1.00	.70	3.00
3	6.00	7.50	10.00	3.80	2.90	1.80	1.60	.90	1.00	.90	.80	5.00
4	5.00	5.00	9.00	4.00	2.70	1.80	1.60	.80	.90	.90	.80	4.00
5	4.00	4.00	8.00	3.80	2.50	1.80	1.60	.80	1.00	1.00	.80	3.00
6	3.00	3.90	6.50	3.40	2.70	1.70	1.60	.90	.90	.90	1.00	2.00
7	2.90	3.80	5.00	3.60	2.60	1.90	1.70	.90	.80	.80	2.00	1.30
8	2.90	3.80	4.00	3.80	2.50	2.50	1.50	.80	1.00	.80	1.70	1.70
9	2.80	3.70	3.50	3.70	2.40	2.30	1.50	.80	.90	.80	.90	1.50
10	2.80	3.70	3.50	3.40	2.40	1.80	1.50	1.00	.80	.90	.90	1.40
11	2.70	3.60	3.90	3.30	2.40	1.70	1.60	2.10	.80	1.40	.80	1.20
12	2.70	3.60	3.80	3.30	2.30	1.70	1.50	1.80	2.00	1.00	.70	1.10
13	2.80	3.50	3.70	3.30	2.30	1.60	1.50	1.50	1.50	.90	.70	1.10
14	2.80	3.40	3.50	3.20	2.20	1.60	1.40	1.00	1.10	2.50	.80	1.00
15	2.70	3.40	3.40	3.20	2.20	1.70	1.40	.90	.90	1.40	.80	1.00
16	2.60	3.50	6.40	3.10	2.30	1.80	1.30	.90	.80	1.20	.70	3.00
17	2.60	3.50	5.20	3.10	2.30	1.70	1.30	.90	.80	.90	1.60	2.00
18	2.50	3.50	3.80	3.20	2.50	1.50	1.30	1.00	.80	.90	1.50	1.80
19	2.60	3.60	4.70	3.00	2.30	1.50	1.20	.90	.90	.80	1.10	1.70
20	2.50	3.70	4.40	2.90	2.20	1.40	1.20	.80	1.90	.80	.90	1.60
21	2.40	3.80	3.40	2.90	2.40	1.40	1.20	.90	1.10	.80	.90	6.50
22	2.50	4.00	3.30	2.80	2.20	1.50	1.20	1.00	.90	.90	1.00	4.00
23	2.50	4.00	3.30	2.90	2.10	1.50	1.10	.90	.90	.90	1.20	2.50
24	2.40	3.80	3.30	2.90	2.00	1.60	1.10	.80	1.00	.80	1.50	2.00
25	2.40	3.60	3.30	2.90	1.90	1.60	1.10	.80	1.20	.80	6.50	1.70
26	2.40	3.50	3.40	2.80	2.00	1.50	1.00	.80	2.00	.80	4.50	1.50
27	2.50	4.00	3.50	2.80	2.00	1.40	1.00	.90	1.30	.70	4.00	1.30
28	2.50	23.00	4.20	2.80	1.90	1.40	.90	1.00	1.10	.70	3.50	1.20
29	2.60	.....	18.00	2.90	1.90	1.50	.90	1.40	.90	.80	3.00	2.20
30	2.90	.....	5.00	3.00	1.80	1.60	.90	1.10	.90	.80	2.50	2.00
31	3.50	.....	4.70	.....	1.80	.....	.90	.90	.....	.80	.....	1.80

Rating table for Coosawattee River at Carters, Ga.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	280	3.8	1,750	6.8	3,846	12.0	7,590
1.0	345	4.0	1,875	7.0	3,990	13.0	8,310
1.2	420	4.2	2,010	7.2	4,134	14.0	9,030
1.4	495	4.4	2,145	7.4	4,278	15.0	9,750
1.6	575	4.6	2,280	7.6	4,422	16.0	10,470
1.8	670	4.8	2,415	7.8	4,566	17.0	11,190
2.0	765	5.0	2,550	8.0	4,710	18.0	11,910
2.2	865	5.2	2,694	8.2	4,854	19.0	12,630
2.4	970	5.4	2,838	8.4	4,998	20.0	13,350
2.6	1,075	5.6	2,982	8.6	5,142	21.0	14,070
2.8	1,180	5.8	3,126	8.8	5,286	22.0	14,790
3.0	1,290	6.0	3,270	9.0	5,430	23.0	15,510
3.2	1,400	6.2	3,414	9.5	5,790		
3.4	1,510	6.4	3,558	10.0	6,150		
3.6	1,625	6.6	3,702	11.0	6,870		

Estimated monthly discharge of Coosawattee River at Carters, Ga.

[Drainage area, 531 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	5,430	970	1,487	2.80	3.23
February	15,510	1,510	2,622	4.94	5.14
March	11,910	1,455	3,127	5.89	6.79
April	1,875	1,180	1,437	2.71	3.02
May	1,290	670	927	1.75	2.02
June	1,022	495	614	1.16	1.29
July	622	310	469	0.88	1.01
August	815	280	350	0.66	0.76
September	765	280	375	0.71	0.79
October	1,022	250	337	0.63	0.73
November	3,630	250	676	1.27	1.42
December	3,630	345	914	1.72	1.98
The year	15,510	250	1,111	2.09	28.18

BLACK WARRIOR RIVER AT TUSCALOOSA, ALA.

The Black Warrior River above Tuscaloosa is largely in a Carboniferous formation, containing pervious strata, porous shales, and limestone caves, through which a good deal of water is probably lost at low season. A continuous record of gage heights at Tuscaloosa since 1889 has been kept by the United States Engineer Corps. During 1895 and 1896 a number of discharge measurements were also made from which a rating table was obtained, and since that time measurements of flow have been made regularly by the United States Geological Survey, and computations made of the discharge. The gage is located about three-fourths of a mile from the business center of Tuscaloosa, Ala. It is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet. It consists of an inclined timber 2 by 6 inches, supported on posts and graduated by means of notches placed 1 foot apart vertically. There are two bench marks: one on a willow tree, 10 feet west of the gage, and 97.84 feet above the Mobile datum; the other on a small hackberry, 30 feet south of the upper end of the gage and 139.36 feet above the Mobile datum. The zero of the gage is 87.30 feet above the Mobile datum. The discharge measurements are made from the highway bridge above the gage. The channel is straight and unobstructed. The current is sluggish at times of low water. The banks are high and rocky and not subject to overflow. Daily gage heights are furnished to the Survey by R. C. McCalla, United States assistant engineer.

Daily gage height, in feet, of Black Warrior River at Tuscaloosa, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	44.00	37.80	49.87	52.88	10.85	1.52	0.35	0.04	2.52	5.61	4.90	8.50
2	38.80	47.50	48.10	45.50	9.90	1.48	.30	.05	2.20	5.50	4.89	9.50
3	34.10	48.40	44.00	39.70	8.32	1.40	.15	.08	2.85	5.00	4.89	13.55
4	28.50	45.00	37.50	35.00	6.51	1.52	.00	.15	4.87	5.50	4.90	17.10
5	24.80	40.00	33.50	32.00	5.50	1.40	.00	1.80	4.65	5.52	4.91	17.92
6	21.15	36.00	35.78	29.00	5.00	1.30	.03	2.30	3.50	5.31	4.94	15.65
7	15.50	31.00	35.00	26.91	4.75	1.25	.05	1.90	2.52	5.15	5.00	14.90
8	14.00	28.15	31.61	32.70	5.11	1.15	.05	1.35	2.00	5.00	4.94	13.40
9	12.50	24.38	28.50	35.75	5.15	1.10	.15	.81	1.60	4.95	4.94	11.75
10	11.00	21.50	25.51	32.81	4.75	1.05	.20	.69	1.32	4.90	4.89	10.25
11	9.30	18.00	23.10	29.05	4.35	1.00	.25	.49	1.12	9.65	4.89	9.10
12	8.50	15.40	20.40	26.00	4.05	.91	.25	.48	.85	15.40	4.90	8.50
13	8.00	13.00	17.70	23.32	3.75	.80	.15	39	.71	14.90	4.90	8.05
14	7.30	11.00	15.52	20.61	3.52	.72	.15	.25	.50	11.75	4.91	7.85
15	6.70	11.50	15.00	18.00	3.15	.70	.10	.18	.40	8.98	4.90	7.45
16	6.11	19.85	17.50	15.82	3.50	.65	.10	.15	.25	7.45	4.89	15.00
17	5.65	21.81	31.80	14.41	6.01	.53	.05	.14	.15	6.40	4.90	29.65

Daily gage height, in feet, of Black Warrior River at Tuscaloosa, Ala.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
18	5.00	19.70	29.60	12.93	6.52	.50	.05	.10	.12	6.00	5.25	28.85
19	6.05	17.55	25.00	11.85	6.10	.80	.04	.08	.75	5.83	5.50	23.90
20	7.81	16.00	21.30	10.57	5.31	1.00	.03	.05	2.21	5.75	5.54	19.15
21	11.00	14.51	18.50	9.61	4.55	1.60	.03	.04	3.51	5.60	5.50	16.30
22	16.15	14.00	17.65	8.80	3.90	1.70	.04	.10	3.92	5.60	5.50	18.00
23	20.81	13.60	15.21	8.05	3.50	1.72	.04	.12	4.30	5.52	5.45	20.30
24	20.81	13.05	13.80	7.72	3.05	1.80	.10	.15	4.50	5.45	5.42	18.10
25	18.50	12.50	18.30	7.30	2.82	1.85	.11	.10	4.75	5.35	5.69	15.41
26	16.85	13.00	19.00	7.05	2.75	1.50	.10	.08	4.83	5.29	6.75	13.50
27	15.50	14.00	35.50	6.72	2.35	1.10	.11	.15	4.90	5.00	13.90	12.00
28	20.00	41.61	60.35	6.41	2.03	.65	.07	.61	5.20	4.90	13.40	10.95
29	28.00	.....	60.60	5.90	1.95	.40	.05	1.45	5.08	4.91	10.42	10.00
30	27.87	.....	58.30	5.75	1.81	.40	.05	1.68	5.65	4.90	9.65	11.10
31	28.50	.....	57.40	.....	1.65	.....	.04	1.98	.....	4.92	.....	12.51

Rating table for Black Warrior River at Tuscaloosa, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
24.0	14,700	28.0	20,900	32.0	28,500	44.0	61,700
24.2	14,960	28.2	21,260	32.5	29,550	45.0	65,250
24.4	15,220	28.4	21,620	33.0	30,600	46.0	69,000
24.6	15,480	28.6	21,980	33.5	31,700	47.0	72,750
24.8	15,740	28.8	22,340	34.0	32,800	48.0	76,500
25.0	16,000	29.0	22,700	34.5	33,900	49.0	80,250
25.2	16,300	29.2	23,080	35.0	35,000	50.0	84,000
25.4	16,600	29.4	24,460	35.5	36,250	51.0	87,750
25.6	16,900	29.6	24,840	36.0	37,500	52.0	91,500
25.8	17,200	29.8	25,220	36.5	38,850	53.0	95,250
26.0	17,500	30.0	24,600	37.0	40,200	54.0	99,000
26.2	17,840	30.2	24,980	37.5	41,600	55.0	102,750
26.4	18,180	30.4	25,360	38.0	43,000	56.0	106,500
26.6	18,520	30.6	25,740	38.5	44,500	57.0	110,250
26.8	18,860	30.8	26,120	39.0	46,000	58.0	114,000
27.0	19,200	31.0	26,500	39.5	47,500	59.0	117,750
27.2	19,540	31.2	26,900	40.0	49,000	60.0	121,500
27.4	19,880	31.4	27,300	41.0	52,000		
27.6	20,220	31.6	27,700	42.0	55,100		
27.8	20,560	31.8	28,100	43.0	58,300		

Estimated monthly discharge of Black Warrior River at Tuscaloosa, Ala.

[Drainage area, 4,900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	61,700	2,555	12,712	2.59	2.99
February	78,000	5,885	21,987	4.49	4.68
March	123,750	7,435	36,776	7.51	8.66
April	94,875	2,971	18,707	3.82	4.26
May	5,800	850	2,349	.48	.55
June	932	400	648	.13	.15
July	385	280	311	.06	.07
August	1,135	295	477	.10	.12
September	2,915	310	1,444	.29	.32
October	8,305	2,500	3,393	.69	.80
November	7,495	2,500	3,136	.64	.71
December	24,935	3,895	8,353	1.70	1.96
The year	123,750	280	9,191	1.88	25.27

BLACK WARRIOR RIVER NEAR CORDOVA, ALA.

This station is located at the Kansas City, Memphis and Birmingham Railroad bridge, which crosses the river below the junction of the Mulberry and Spipsey Forks, or about three-fourths of a mile from Cordova, Ala. The gage was established by the United States Weather Bureau, but observations were discontinued by that Bureau some time ago. From 12 to 55 feet the gage is a vertical timber bolted to the inside of the bridge pier on the left bank of the river. Below 12 feet the gage was sloping, but it was out of position and could not be used when the station was established by the Geological Survey on May 21, 1900, so a short new section was put in at that time. This section is a 2-inch by 10-inch plank, graduated to feet and tenths, marked with nails from −1.5 feet to +12.5 feet, and spiked to a willow tree on the right bank of the river about 200 feet below the bridge. The bench mark is the top of the stone pier on the left bank, and is 54.95 feet above the zero of the gage. Measurements are made from the railroad bridge, which is a single-span, iron, through bridge 300 feet long. The section is a good one. The observer, C. F. Diffenderfer, is employed by the United States Engineer Corps, and daily gage heights are furnished through the kindness of R. C. McCalla, United States assistant engineer.

The following discharge measurements were made during 1902:

January 17: Gage height, 0.80 feet; discharge, 1,384 second-feet.
April 4: Gage height, 5.80 feet; discharge, 7,162 second-feet.
September 22: Gage height, —1.10 feet; discharge, 74 second-feet.[a]
October 14: Gage height, 0.60 feet; discharge, 834 second-feet.

Daily gage height, in feet, of Black Warrior River near Cordova, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.80	14.60	22.60	18.10	0.80	−0.60	−0.90	−1.00	−0.80	−0.40	−0.80	0.70
2	6.50	18.10	15.00	9.20	.60	− .70	− .90	−1.00	− .80	− .20	− .80	2.80
3	5.00	15.40	8.60	6.50	.50	− .70	− .90	.00	− .70	− .10	− .80	7.20
4	4.20	10.50	6.50	5.70	.30	− .70	− .90	− .10	− .60	− .40	− .80	7.00
5	3.70	8.00	8.80	5.40	.20	− .70	− .90	− .10	− .70	− .60	− .80	3.60
6	3.00	6.20	11.50	4.30	.10	− .70	− .90	− .30	− .80	− .60	− .70	3.80
7	2.60	5.20	8.40	5.75	.00	− .70	−1.00	− .50	− .90	− .70	− .60	3.20
8	2.40	4.40	6.70	8.90	.00	− .80	−1.00	− .80	−1.00	− .70	− .40	2.40
9	2.20	3.80	6.10	8.10	− .10	− .80	−1.00	−1.00	−1.00	− .70	− .40	1.80
10	2.00	3.30	5.70	6.40	− .10	− .80	−1.00	−1.00	−1.10	− .70	− .50	1.30
11	1.80	2.80	4.90	5.00	.00	− .80	−1.00	−1.10	−1.10	+ .60	− .60	1.00
12	1.60	2.50	4.30	4.20	− .10	− .80	−1.10	−1.10	−1.10	2.90	− .70	.80
13	1.40	2.30	4.10	3.80	− .20	− .80	−1.10	−1.10	−1.10	1.40	− .70	.70
14	1.20	2.20	3.80	3.50	− .20	− .80	−1.10	−1.10	−1.10	.60	− .70	.60
15	1.10	5.30	3.50	3.20	− .20	− .90	−1.10	−1.10	−1.10	.60	− .70	.50
16	1.00	7.50	3.80	2.80	.10	− .90	−1.10	−1.10	−1.10	.20	− .70	6.50
17	1.00	5.50	7.10	2.30	.20	− .90	−1.10	−1.10	−1.10	− .20	− .70	11.30
18	.90	4.70	5.30	2.00	.50	− .90	−1.10	−1.10	−1.10	− .30	− .50	6.30
19	1.70	4.20	4.10	1.70	.30	− .90	−1.10	−1.10	−1.10	− .40	− .50	4.40
20	3.00	3.70	3.80	1.60	.20	− .90	−1.00	−1.10	−1.10	− .50	− .50	3.20
21	3.50	3.40	3.60	1.40	.00	− .40	−1.00	−1.10	−1.10	− .60	− .50	3.70
22	6.70	3.30	3.60	1.20	− .20	− .20	− .90	−1.00	−1.10	− .60	− .50	5.80
23	6.00	3.00	3.10	1.10	− .30	− .60	− .90	−1.00	−1.10	− .60	− .50	4.40
24	4.80	2.70	2.70	1.00	− .40	− .70	− .90	−1.00	−1.10	− .70	− .50	3.50
25	4.30	3.20	3.50	.90	− .50	− .70	− .90	−1.00	−1.10	− .80	− .20	2.70
26	3.90	4.00	3.30	.80	− .50	− .70	−1.00	−1.10	−1.00	− .80	8.00	2.40
27	5.00	4.00	8.10	.70	− .50	− .80	−1.00	−1.10	−1.00	− .80	3.40	1.80
28	12.00	22.70	25.00	.60	− .50	− .80	−1.00	− .90	−1.10	− .80	1.50	1.60
29	10.30	.....	35.50	.50	− .60	− .80	−1.00	− .70	−1.10	− .80	.80	2.40
30	8.30	.....	39.00	1.00	− .60	− .80	−1.00	− .60	− .80	− .80	.60	2.50
31	11.00	.....	31.80	.....	− .70	.....	−1.00	− .70	.....	− .80	.....	2.70

[a] Estimated from float measurement.

Rating table for Black Warrior River near Cordova, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−1.0	95	2.8	3,404	7.5	10,360	17.0	24,420
−.8	160	3.0	3,700	8.0	11,100	17.5	25,160
−.6	260	3.2	3,996	8.5	11,840	18.0	25,900
−.4	384	3.4	4,292	9.0	12,580	19.0	27,380
−.2	518	3.6	4,588	9.5	13,320	20.0	28,860
.0	660	3.8	4,884	10.0	14,060	21.0	30,340
.2	810	4.0	5,180	10.5	14,800	22.0	31,820
.4	968	4.2	5,476	11.0	15,540	23.0	33,300
.6	1,134	4.4	5,772	11.5	16,280	24.0	34,780
.8	1,307	4.6	6,068	12.0	17,020	25.0	36,260
1.0	1,486	4.8	6,364	12.5	17,760	26.0	37,740
1.2	1,669	5.0	6,660	13.0	18,500	27.0	39,220
1.4	1,856	5.2	6,956	13.5	19,240	28.0	40,700
1.6	2,047	5.4	7,252	14.0	19,980	29.0	42,180
1.8	2,242	5.6	7,548	14.5	20,720	30.0	43,660
2.0	2,444	5.8	7,844	15.0	21,460	31.0	45,140
2.2	2,652	6.0	8,140	15.5	22,200	32.0	46,620
2.4	2,868	6.5	8,880	16.0	22,940	33.0	48,100
2.6	3,118	7.0	9,620	16.5	23,680	34.0	49,580

Estimated monthly discharge of Black Warrior River near Cordova, Ala.

[Drainage area, 1,900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	17,020	1,396	5,692	3.00	3.46
February	32,856	2,652	8,599	4.53	4.72
March	56,980	3,258	13,764	7.24	8.35
April	26,048	1,050	5,366	2.82	3.15
May	1,307	205	630	.33	.38
June	518	125	193	.10	.11
July	125	74	99	.05	.06
August	660	74	170	.09	.10
September	260	74	105	.06	.07
October	3,552	160	536	.28	.32
November	11,100	160	880	.46	.51
December	15,984	1,050	4,395	2.31	2.66
The year	56,980	74	3,369	1.77	23.89

BLACK WARRIOR RIVER (LOCUST FORK OF) AT PALOS, ALA.

Locust Fork of Black Warrior River rises in Blount County, Ala., and flowing in a southwesterly course enters Black Warrior River a short distance above Wilmington, Ala. Its drainage basin is hilly, and about half its area is in cultivation. Palos station was established November 26, 1901, by R. C. McCalla, United States assistant engineer, who furnishes the daily gage heights to the Geological Survey. It is maintained by the United States Engineer Corps. The gage is a 4 by 8 inch timber, on the right bank of Locust Fork of Black Warrior River, just below the Kansas City, Memphis and Birmingham Railroad bridge. One section follows the slope of the bank from low water to a tree on top of the bank, and from there up a vertical section is fastened to the tree. The slope is 17 feet in elevation, measured vertically, and the vertical section of the rod is 15 feet. The rod is graduated to feet and tenths, with copper figures at the 5-foot points, and round-head tacks at intermediate foot marks. The total height is 32 feet. The plane of reference (about 251.71 feet above Mobile datum) is supposed to be extreme low water. High water, April, 1900, was about 37 feet above the plane of reference.

Measurements are made from the Drennan bridge, which is about a quarter of a mile below the Kansas City, Memphis and Birmingham Railroad bridge. The Drennan bridge is the property of the Drennan Coal Mining Company. It is a mining railroad bridge, having width for a double-track tramway of 3-feet gage. One track is laid and in operation. The bridge has two iron spans of 100 feet each, and trestle approaches at both ends.

The initial point for measurements is the left-bank end of the iron bridge on the downstream side.

The bench mark is the top of the iron crossbeam at station 80 from the initial point, and was 44.3 feet above the water when the gage read 2.50 feet.

This bridge is lower and the section is better than that at the upper bridge, from which some of the measurements have been made; but there is a raft against the center pier that should be removed. At minimum stages the water at both bridges is too sluggish for accurate measurement.

Discharge measurements of Black Warrior River (Locust Fork of) at Palos, Ala.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 18	K. T. Thomas	0.85	849
April 5	do	2.50	3,224
Do	do	2.50	3,292
September 20	J. C. Conn	.00	[a] 117
October 15	do	.60	473

[a] Estimated from float measurement.

Daily gage height, in feet, of Black Warrior River (Locust Fork of) at Palos, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.50	8.30	13.30	4.90	0.90	0.20	0.10	0.40	0.10	0.10	0.00	1.10
2	3.40	12.80	6.70	3.50	.80	.20	.10	.30	.00	.10	.00	1.10
3	2.70	10.20	4.40	2.70	.70	.20	.10	30	.00	.10	.00	1.90
4	2.20	5.70	3.00	2.60	.70	.20	.10	.90	.00	.10	.00	1.90
5	2.00	3.90	5.00	2.50	.60	.20	.10	.30	.00	.10	.00	1.70
6	1.70	3.00	5.30	2.30	.60	.20	.00	.20	.00	.10	.00	1.60
7	1.60	2.40	3.70	2.10	.50	.20	.00	.10	.00	.10	.00	1.50
8	1.50	2.00	3.00	5.80	.50	.20	.00	.10	.00	.00	.00	1.20
9	1.30	1.80	2.50	5.00	.50	.20	.10	.10	.00	.00	.00	1.00
10	1.30	1.70	2.10	3.40	.50	.20	.10	.00	.00	.00	.00	.90
11	1.20	1.60	1.90	2.60	.40	.10	.10	.00	.00	1.70	.00	.80
12	1.10	1.50	1.70	2.20	.40	.10	.10	.00	.00	2.00	.00	.70
13	1.10	1.40	1.60	2.00	.40	.10	.10	.00	.00	1.30	.00	.70
14	1.00	1.30	1.60	1.80	.40	.10	.10	.00	.00	.80	.00	.60
15	.90	2.20	1.50	1.70	.40	.10	.10	.00	.00	.60	.00	.60
16	.90	2.80	3.40	1.60	.30	.10	.00	.00	.00	.40	.00	3.10
17	.90	2.20	4.50	1.50	.60	.10	.00	.00	.00	.40	.00	3.30
18	.90	2.00	3.00	1.50	.50	.10	.00	.00	.00	.30	.20	2.40
19	1.00	1.80	2.30	1.40	.50	.10	.00	.00	.00	.20	.20	1.90
20	1.10	1.70	2.00	1.30	.40	.10	.00	.00	.00	.20	.20	1.50
21	1.60	1.60	1.80	1.10	.40	.10	.10	.00	.00	.10	.20	1.60
22	2.50	1.60	1.70	1.00	.40	.10	.10	.00	.00	.10	.20	2.50
23	2.40	1.50	1.60	1.00	.40	.10	.00	.00	.00	.10	.20	2.20
24	2.30	1.50	1.50	.90	.30	.10	.00	.00	.00	.00	.10	1.80
25	2.40	1.80	1.90	.90	.30	.10	.00	.00	.00	.00	.20	1.50
26	1.90	1.60	1.70	.90	.30	.10	.00	.00	.00	.00	1.10	1.30
27	1.80	2.20	6.30	.80	.30	.10	.00	.00	.00	.00	1.40	1.10
28	2.10	14.90	24.00	.80	.20	.10	.10	.00	.10	.00	1.10	1.00
29	3.10	.....	27.00	.70	.20	.20	.10	.10	.00	.00	.80	1.00
30	3.30	.....	25.00	1.20	.20	.20	.20	.10	.10	.00	.60	1.20
31	3.60	.....	17.90	.....	.20	.....	.50	.10	.....	.00	.....	1.40

Rating table for Black Warrior River (Locust Fork of) at Palos, Ala., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	100	0.9	900	1.8	2,250	2.7	3,600
.1	140	1.0	1,050	1.9	2,400	2.8	3,750
.2	190	1.1	1,200	2.0	2,550	2.9	3,900
.3	245	1.2	1,350	2.1	2,700	3.0	4,050
.4	310	1.3	1,500	2.2	2,850	3.1	4,200
.5	390	1.4	1,650	2.3	3,000	3.2	4,350
.6	490	1.5	1,800	2.4	3,150	3.3	4,500
.7	610	1.6	1,950	2.5	3,300	3.4	4,650
.8	750	1.7	2,100	2.6	3,450	3.5	4,800

Estimated monthly discharge of Black Warrior River (Locust Fork of) at Palos, Ala.

[Drainage area, 1,020 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	7,800	900	2,468	2.42	2.79
February	21,900	1,500	4,746	4.65	4.84
March	40,050	1,800	8,400	8.24	9.50
April	8,250	610	2,635	2.58	2.88
May	900	190	374	.37	.43
June	190	140	160	.16	.18
July	390	100	133	.13	.15
August	900	100	157	.15	.17
September	140	100	104	.10	.11
October	2,550	100	359	.35	.40
November	1,650	100	282	.28	.31
December	4,500	490	1,784	1.75	2.02
The year	21,900	100	1,800	1.76	23.78

TOMBIGBEE RIVER AT COLUMBUS, MISS.

This station is located about 1,000 feet below the county highway bridge, 1½ miles from the Southern Railway depot at Columbus. The rod is fastened vertically to the rock bluff on the left bank. It is a 3 by 10 inch pine timber, 45 feet long, marked with brass figures and copper nails, the graduations extending from −5 feet to +40 feet. The initial point of sounding is the end of the iron bridge, on the right bank, downstream side. Bench mark No. 1 is 250 feet from the initial point of sounding. The bridge floor at this point is 40.85 feet above the zero of the rod, and the top of the iron girder under the floor timbers is 39.85 feet above the zero. Bench mark No. 2 is the top of the rail at the depot of the Southern Railway, and is 55.2 feet above gage datum and 190.9 above mean sea level. Measurements are made from the county highway bridge. The width of the river at low water is 160 feet. The maximum recorded height of the river was on April 8, 1892, when the gage registered 42 feet. The lowest recorded height was on October 26, 1893, when the gage reading was −3.9 feet. The danger line is at 33 feet. The observer, J. J. Richards, is paid by the United States Weather Bureau.

Discharge measurements of Tombigbee River at Columbus, Miss.

Date.	Hydrographer	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 3	K. T. Thomas	27.60	45,214
July 11	J. C. Conn	-3.40	697
July 15	do	-2.70	1,058
September 23	do	-3.25	545
September 26	do	-3.30	493

Daily gage height, in feet, of Tombigbee River at Columbus, Miss.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	9.20	14.50	9.50	30.30	0.00	-2.60	-3.20	-2.60	-2.40	-2.20	-3.30	3.80
2	8.90	16.80	9.30	29.40	-.50	-2.50	-3.20	-1.30	-2.70	-1.80	-3.30	3.90
3	7.70	17.90	9.30	28.20	-1.50	-2.50	-3.20	-.50	-2.40	-.90	-3.30	4.90
4	5.80	18.50	9.20	26.30	-.90	-2.60	-3.20	-.20	-2.20	-.60	-3.30	5.10
5	4.00	19.00	9.80	23.70	-.20	-2.60	-3.20	-.10	-2.50	-1.00	-3.30	5.70
6	2.50	17.60	9.20	20.50	-.10	-2.70	-3.30	-.40	-2.20	-1.30	-3.20	5.70
7	1.50	16.00	8.20	18.20	-.40	-2.70	-3.30	-1.00	-2.20	-1.60	-3.10	4.90
8	.90	13.60	7.80	18.90	-.60	-2.80	-3.30	-1.60	-2.10	-2.00	-3.10	4.60
9	.50	10.70	7.00	18.30	-.40	-2.80	-3.40	-2.00	-2.20	-2.30	-3.00	3.90
10	.10	7.60	6.00	17.80	-.20	-2.90	-3.40	-2.30	-2.40	-2.50	-2.90	3.00
11	-.20	5.60	6.00	17.40	-.50	-2.80	-3.20	-2.70	-2.70	-2.90	-3.00	2.20
12	-.20	3.00	4.20	16.00	-.80	-2.90	-3.40	-2.90	-3.00	-2.60	-3.00	1.50
13	-.50	2.10	4.30	13.00	-1.00	-2.80	-3.00	-3.00	-3.20	-2.70	-3.10	.80
14	-.60	1.40	4.30	9.00	-1.30	-2.90	-2.50	-3.10	-3.30	-2.50	-3.10	.60
15	-.90	4.00	4.80	5.60	-1.50	-3.00	-2.70	-3.20	-3.40	-2.20	-3.10	.60
16	-1.00	5.40	6.00	4.20	-1.60	-3.10	-3.00	-3.30	-3.50	-2.20	-3.00	1.20
17	-1.00	5.60	7.40	3.50	-1.10	-3.20	-3.10	-3.30	-3.50	-2.00	-3.00	1.90
18	-1.00	5.90	7.60	3.00	-1.30	-3.20	-3.20	-3.30	-3.50	-2.50	-3.00	11.10
19	-.60	5.60	7.50	2.70	-1.10	-3.20	-3.30	-3.40	-3.50	-2.50	-3.00	11.80
20	+.50	4.60	6.79	2.20	-1.10	-3.20	-3.30	-3.40	-3.50	-2.60	-3.00	13.00
21	3.10	4.40	5.70	2.00	-1.00	-3.10	2.70	-3.40	-3.40	-2.90	-2.90	13.20
22	5.20	5.30	4.70	1.80	-1.20	-3.00	-3.00	-3.50	-3.30	-3.00	-2.90	14.80
23	5.60	5.60	3.50	1.60	-1.50	-2.90	-3.00	-3.50	-3.30	-3.00	-2.90	13.80
24	5.80	5.30	4.00	1.10	-1.70	-2.80	-2.90	-3.50	-3.30	-3.00	-2.90	12.10
25	5.50	6.40	6.40	.90	-1.90	-3.00	-2.90	-3.60	-3.40	-3.10	-1.40	10.00
26	4.60	5.80	6.10	.70	-2.10	-3.00	-2.80	-3.60	-3.40	-3.10	.30	10.40
27	4.00	5.70	13.40	.60	-2.20	-3.00	-2.90	-3.60	-3.30	-3.10	1.20	10.60
28	6.10	8.10	21.00	.40	-2.30	-3.00	-2.90	-3.10	-3.20	-3.20	2.50	10.80
29	7.40	.....	28.00	.30	-2.40	-3.10	-2.60	-3.00	-3.10	-3.30	2.90	11.30
30	10.00	.....	30.50	.30	2.50	-3.20	-3.00	-2.50	-2.90	-3.30	3.50	10.40
31	12.40	.....	30.60	.....	-2.50	.....	-3.00	-2.40	.....	-3.30	.....	9.50

Rating table for Tombigbee River at Columbus, Miss.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
—3.4	500	0.2	3,230	6.5	10,400	15.5	24,750
—3.2	630	.4	3,410	7.0	11,100	16.0	25,600
—3.0	760	.6	3,590	7.5	11,815	17.0	27,300
—2.8	890	.8	3,780	8.0	12,540	18.0	29,000
—2.6	1,030	1.0	3,970	8.5	13,290	19.0	30,700
—2.4	1,170	1.2	4,160	9.0	14,040	20.0	32,400
—2.2	1,310	1.4	4,350	9.5	14,815	21.0	34,100
—2.0	1,450	1.6	4,550	10.0	15,590	22.0	35,800
—1.8	1,590	1.8	4,750	10.5	16,370	23.0	37,500
—1.6	1,740	2.0	4,950	11.0	17,170	24.0	39,200
—1.4	1,890	2.5	5,475	11.5	17,975	25.0	40,900
—1.2	2,040	3.0	6,020	12.0	18,800	26.0	42,600
—1.0	2,190	3.5	6,585	12.5	19,650	27.0	44,300
— .8	2,350	4.0	7,170	13.0	20,500	28.0	46,000
— .6	2,520	4.5	7,775	13.5	21,350	29.0	47,700
— .4	2,690	5.0	8,400	14.0	22,200	30.0	49,400
— .2	2,870	5.5	9,050	14.5	23,050		
.0	3,050	6.0	9,720	15.0	23,900		

Estimated monthly discharge of Tombigbee River at Columbus, Miss.

[Drainage area, 4,440 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	19,480	2,190	7,009	1.58	1.82
February	30,700	4,350	14,148	3.19	3.32
March	50,420	6,585	15,583	3.51	4.05
April	49,910	3,320	18,180	4.09	4.56
May	3,050	1,100	2,060	.46	.53
June	1,100	630	825	.19	.21
July	1,100	500	717	.16	.18
August	2,960	370	1,095	.25	.29
September	1,380	435	790	.18	.20
October	2,520	565	1,165	.26	.30
November	6,585	565	1,482	.33	.37
December	23,560	3,590	11,730	2.64	3.04
The year	50,420	370	6,232	1.40	18.87

MISCELLANEOUS MEASUREMENTS IN MOBILE RIVER DRAINAGE BASIN.

The following miscellaneous measurements were taken in the Mobile drainage basin during 1902 by B. M. Hall and his assistants:

Date.	Stream.	Locality.	Discharge.
Apr. 4	Luxapelila Creek	City waterworks, Columbus, Miss. (gage height, 12.4 feet).	3,864
June 2	Tallapoosa River	Tallapoosa, Ga. (gage height, 1.30 feet).	114
June 11	Etowah River	Euharlee, Ga., 8 miles south of Kingston, Ga.	1,393
June 11	Etowah River	Four miles south of Kingston, Ga	1,631
June 24	Euharlee Creek	Rockmart, Ga. (gage height, 1 foot)	25
July 11	Luxapelila Creek	City waterworks, Columbus, Miss. (gage height, 1.60 feet).	141
July 22	Etowah River	Loopers Bridge, south of Dawson, Ga.	136
Sept. 23	Luxapelila Creek	City waterworks, Columbus, Miss. (gage height, 1.70 feet).	322
Sept. 25	Euharlee Creek	Rockmart, Ga	41
Oct. 8	Euharlee Creek	Rockmart, Ga. (gage height, 0.60 foot).	13
Nov. 4	Talking Rock Creek	Near Carters, Ga. (gage height, 0.85 foot).	55

PEARL RIVER DRAINAGE BASIN.

Pearl River rises in the eastern part of Mississippi. It flows south into Lake Borgne, an arm of the Gulf of Mexico, forming part of the boundary between Louisiana and Mississippi. The United States Geological Survey maintains one station on this river, under the direction of B. M. Hall. It is located at Jackson, Miss.

PEARL RIVER AT JACKSON, MISS.

This station was established June 24, 1901, by the United States Geological Survey, and is situated at the highway bridge 2 miles from the union station of Jackson and one-eighth of a mile above the Alabama and Vicksburg Railway bridge.

The gage is a wire gage fastened to the guard timber on the downstream side of the bridge. The rod is 10 feet long, graduated to feet and tenths, and is marked with staples and brass figures. Above 10 feet the guard timber is marked. The bench mark is the downstream end of the top of the iron crossbeam 120 feet from the right-bank end of the bridge. This end of the bridge is the initial point for soundings. The elevation of the bench mark is 39 feet above datum. The bridge floor at the same point is 40.15 feet above datum. The observer is James Hurst.

During 1902 the following discharge measurements were made:

July 14: Gage height, 1.10 feet; discharge, 193 second-feet.
September 25: Gage height, 0.90 foot; discharge, 290 second-feet.

Daily gage height, in feet, of Pearl River at Jackson, Miss.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	15.00	13.90	13.00	37.20	6.00	2.20	1.30	1.30	7.90	1.90	1.00	3.10
2	15.20	16.60	13.00	36.20	5.90	2.20	1.30	1.20	4.80	2.00	1.00	4.60
3	15.10	17.10	13.00	34.60	5.60	2.10	1.30	1.70	3.60	2.40	1.00	4.10
4	15.00	18.30	13.20	33.10	5.10	2.00	1.20	1.70	3.40	2.80	1.00	5.30
5	14.80	18.60	13.40	32.00	4.90	2.00	1.20	1.60	3.20	3.00	1.10	5.80
6	14.50	18.40	13.70	31.00	4.80	1.90	1.20	1.60	2.50	3.60	1.00	6.30
7	14.20	18.30	14.00	30.10	4.60	1.90	1.20	1.40	3.90	3.20	1.00	6.80
8	13.90	18.20	13.80	29.10	4.30	1.80	1.30	1.40	3.80	3.10	1.00	6.40
9	13.40	17.00	13.60	28.10	4.00	1.80	1.30	1.40	3.60	2.90	1.20	6.00
10	12.60	17.70	13.20	27.10	3.90	1.80	1.30	1.40	3.50	2.30	1.20	5.80
11	11.80	17.60	12.00	26.30	3.50	1.80	3.50	1.40	3.60	2.30	1.30	5.70
12	10.80	17.40	12.20	25.60	3.20	1.70	3.00	1.40	3.50	2.60	1.30	5.60
13	10.00	16.90	11.70	24.80	3.20	1.70	1.20	1.40	3.50	2.60	1.30	5.20
14	9.10	15.80	11.90	24.40	3.10	1.70	1.20	1.30	3.90	2.80	1.40	5.70
15	8.10	14.30	10.30	24.00	3.00	1.60	1.20	1.30	3.70	3.00	1.40	5.10
16	8.00	12.60	9.90	23.50	2.10	1.60	1.30	1.30	3.60	3.20	1.40	10.60
17	7.90	10.90	10.60	23.00	2.80	1.50	1.30	1.20	3.40	3.30	1.40	10.70
18	6.70	9.70	10.60	22.30	2.60	1.50	1.20	1.20	3.00	3.60	1.30	10.50
19	5.40	9.00	10.50	21.20	3.00	1.50	1.10	1.10	2.90	3.50	1.30	11.10
20	5.10	8.60	10.00	19.50	2.90	1.40	1.10	1.10	2.60	3.30	1.20	11.30
21	5.40	8.30	9.90	17.20	2.80	1.30	1.10	1.10	2.40	3.20	1.20	11.60
22	5.60	8.20	9.90	14.00	2.60	1.30	1.10	1.10	1.00	2.00	1.20	12.20
23	5.80	8.30	9.90	11.10	2.80	1.30	1.10	.90	1.20	1.90	1.10	12.20
24	6.40	9.00	10.80	9.30	3.00	1.40	1.10	1.00	1.20	1.80	1.80	11.90
25	6.90	10.70	12.90	8.10	3.00	1.40	1.20	.90	1.10	1.50	1.70	11.70
26	6.20	11.40	13.80	7.20	2.80	1.30	1.40	.80	1.30	1.50	1.80	11.10
27	7.00	11.60	22.70	7.10	2.70	1.30	1.40	1.00	1.30	1.40	1.70	10.80
28	7.10	12.30	28.55	6.50	2.60	1.30	1.40	2.30	1.40	1.30	1.60	10.00
29	7.20	.....	30.40	6.40	2.50	1.30	1.40	4.50	1.60	1.20	1.60	10.90
30	8.50	.....	32.10	6.20	2.40	1.30	1.40	7.20	1.80	1.10	2.60	8.00
31	10.10	.....	36.50	.....	2.20	1.30	1.40	7.40	.....	1.10	.....	9.90

EASTERN MISSISSIPPI RIVER DRAINAGE.

For convenience of classification the drainage areas of the tributaries from the east that contribute to the Mississippi River drainage have been grouped together. These tributaries vary widely in character, as regards both the types of the rivers and the topography of the areas which they drain. Those draining the comparatively low rolling country adjacent to the valley of the Mississippi are as a rule sluggish streams, with few falls of importance, while the upper Ohio River and its numerous tributaries drain a country of high elevations, their upper courses being through narrow V-shaped valleys, with frequent falls and with high rocky banks. Owing to the steep slopes the

run-off is rapid, causing sudden fluctuations in the streams and giving rise to the high floods and extreme low waters for which the Ohio Basin is noted, and the influence of which is felt to a marked degree even in the flow of the Mississippi below Cairo.

In this report these drainage areas have been arranged geographically from north to south, and the Ohio River drainage has been divided into its smaller systems. The following are the systems from which the United States Geological Survey has obtained data during 1902: Those which enter the Mississippi above the mouth of the Ohio are the Chippewa, Black, and Wisconsin rivers in Wisconsin, and Rock River and Illinois River. Those that enter the Ohio from the north are the Wabash and the Muskingum. Those entering the Ohio from the south are the Monongahela, the Kanawha, the Cumberland, and the Tennessee. Entering below the mouth of the Ohio is the Yazoo.

CHIPPEWA RIVER DRAINAGE BASIN.

Chippewa River rises in the southeastern part of Ashland County, Wis. It flows southwest, emptying into the Mississippi near Wabasha, Minn. Its principal tributary is the Flambeau, which enters from the east in Gates County. During the latter part of the year 1902, the United States Geological Survey began systematic measurements in this and other drainage basins of Wisconsin. This study is carried on in cooperation with the Wisconsin Geological and Natural History Survey, under the direction of L. S. Smith, hydrographer of the latter survey. The field work is performed by L. R. Stockman.

A gaging station has been established in this basin at Eau Claire, Wis.

CHIPPEWA RIVER NEAR EAU CLAIRE, WIS.

This station was established November 13, 1902, by L. R. Stockman. It is located on the highway bridge, 3 miles from Eau Claire, Wis. The gage is a plain staff graduated to feet and tenths, fastened to the center pier of the bridge. It is read twice daily by R. F. Duncan. The channel is straight for 300 feet above the station and for 800 feet below. The left bank is low and liable to overflow. The right bank is high and rocky; the bed of the stream is sandy gravel. The initial point for soundings is a nail in the foot board at the right end of the bridge. The bench mark is a nail in the top of a 6-inch white-oak stump, 200 feet from the road, and 200 feet from the river; elevation above zero of gage, 20.09 feet.

The following discharge measurements were made during 1902:

November 13: Gage height, 8.7 feet; discharge, 11,134 second-feet.
December 6: Gage height, 4.45 feet; discharge, 2,871 second-feet.
December 28: Gage height, 4.6 feet; discharge, 3,063 second-feet.

Daily gage height, in feet, of Chippewa River near Eau Claire, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		(a)	12		4.20	23	7.15	4.50
2		(a)	13	3.00	4.45	24	7.00	4.70
3		(a)	14	10.20	4.25	25	6.45	4.30
4		(a)	15	12.10	4.55	26	6.20	4.90
5		4.50	16	13.05	4.25	27	6.00	5.10
6		4.45	17	12.60	4.30	28	5.75	5.10
7		4.00	18	10.85	4.10	29	5.55	4.50
8		4.05	19	9.60	4.30	30	(a)	4.85
9		4.05	20	8.50	4.25	31		4.50
10		4.10	21	7.55	4.30			
11		4.25	22	7.40	4.25			

a No readings taken.

BLACK RIVER DRAINAGE BASIN.

Black River rises in Taylor County, Wis., and flows southwest, emptying into the Mississippi about 20 miles above La Crosse. The United States Geological Survey is maintaining a station on this river at Melrose.

BLACK RIVER AT MELROSE, WIS.

This station was established November 12, 1902, by L. R. Stockman. It is located 1 mile south of Melrose, Wis., on the highway bridge. The river at this point flows in two channels, which at present have practically the same elevation. The gage is a plain staff, graduated to feet and tenths, nailed to the piling of the bridge. It is read daily by William H. Westfall. The channel is straight both above and below the station for about 500 feet. The right bank is high and rocky; the left bank is also high. The bed of the stream is sandy and shifting. The initial point for soundings is a nail in the footboard on the right bank. Bench mark No. 1 consists of a nail driven into the root of a 16-inch black oak 50 feet west of the north end of the bridge; elevation 15.23 feet above zero of the gage. Bench mark No. 2 has an elevation of 14.72 above zero of gage. Assuming the elevation of bench mark No. 1 at 1,000, then elevation of bench mark No. 2 is 999.49.

The following discharge measurements were made during 1902:

November 12: Gage height, 4.5 feet; discharge, 1,042 second-feet.
December 26: Gage height, 5.70 feet; discharge, 1,557 second-feet.

Daily gage height, in feet, of Black River at Melrose, Wis.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1902.		1902.		1902.		1902.	
1		9	4.35	17	4.00	25	5.85
2		10	4.30	18	4.00	26	5.80
3		11	4.35	19	4.05	27	5.65
4	3.75	12	4.20	20	4.25	28	5.50
5	3.95	13	4.20	21	4.60	29	5.35
6	4.00	14	4.10	22	4.95	30	5.20
7	3.80	15	4.15	23	5.80		
8	4.35	16	4.10	24	6.05		

WISCONSIN RIVER DRAINAGE BASIN.

Wisconsin River is the largest river in the State of Wisconsin. It rises in the northern part and flows south through the central portion of the State to Portage, where it turns at nearly a right angle and flows west, emptying into the Mississippi about 60 miles above Dubuque.

Gaging stations have been established in this basin at Necedah, Muscoda, and Merrill. These stations divide the river into three nearly equal reaches of about 90 miles each, so furnishing ample opportunity for a systematic study.

WISCONSIN RIVER AT MUSCODA, WIS.

This station was established December 20, 1902, by L. R. Stockman. It is situated three-fourths of a mile north of Muscoda on the toll highway bridge. The gage is a horizontal wire with a scale board graduated to feet and tenths and fastened to the top of the bridge. The initial point of sounding is on the left bank, at the end of the drawbridge. The channel is straight for 1,500 feet and 1,000 feet below. The right bank is low and liable to overflow. The water is confined to the bridge opening. The left bank is high and rocky. The bed of the stream is rocky, with spots of gravel. The gage is read twice a day by Charles H. Lovell, the bridge tender. Bench mark No. 1, elevation 684 feet above sea level; bolt in south end of east guard rail at south end of bridge. Bench mark No. 2, elevation 681.17 feet; nail in root on north side of 20-inch black oak tree standing about 40 paces south by east from the south end of the drawbridge. Bench mark No. 3, elevation 680.95 feet; a projecting point on a sandstone rock on the east end of south abutment near the supporting wheel at end of drawbridge. On the vertical face of the stone is an arrow pointing upward to this point. The stone is also marked B. M. Bench mark No. 4, elevation 684.25 feet; a point marked X on a

foundation stone at the southeast corner of Lampi's brewery. The 15-foot mark has an elevation of 668.62 feet.

The following measurement was made in 1902:

December 20: Gage height, 15 feet; discharge, 6,924 second-feet.

Daily gage height, in feet, of Wisconsin River at Muscoda, Wis.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1902.		1902.		1902.		1902.	
1		9		17		25	14.85
2		10		18		26	14.80
3		11		19		27	14.70
4		12		20		28	14.55
5		13		21	15.05	29	14.55
6		14		22	15.00	30	14.75
7		15		23	15.05	31	14.75
8		16		24	15.05		

WISCONSIN RIVER NEAR NECEDAH, WIS.

This station was established December 2, 1902, by L. R. Stockman. It is located on the highway toll bridge 3 miles east of Necedah, Wis. The gage is a plain staff, graduated to feet and tenths, fastened to the center pier of the bridge. It is read twice daily by Edward Bundy, whose post-office address is Strongs Prairie. The channel is straight both above and below the station. The right bank is high. The left bank is low, but the water is confined to the channel by the bridge except when the gage reads above 11 feet. The bed of the stream is gravel and sand, somewhat liable to shift. The bench mark is a nail in a red-oak stump about 60 feet south of the roadway and 50 feet from the river. Bench mark No. 2, elevation 998.91 feet, is a nail in the root of a large cottonwood tree 28 feet south of the bridge and about 80 feet from the river.

The following discharge measurements were made during 1902:

December 2: Gage height, 4.90 feet; discharge, 3,875 second-feet.
December 23: Gage height, 5.40 feet; discharge, 3,534 second-feet.

Daily gage height of Wisconsin River near Necedah, Wis.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1902.		1902.		1902.		1902.	
1		9	4.85	17	5.65	25	6.40
2	4.90	10	5.25	18	5.30	26	6.35
3	4.95	11	5.20	19	5.50	27	6.60
4	5.10	12	5.40	20	5.45	28	6.15
5	4.85	13	5.25	21	5.30	29	6.05
6	4.75	14	5.30	22	5.30	30	6.20
7	4.70	15	5.35	23	5.40	31	5.95
8	4.30	16	5.65	24	5.62		

WISCONSIN RIVER AT MERRILL, WIS.

This station was established November 17, 1902, by L. R. Stockman. It is located on the highway bridge at the east end, in the city of Merrill, Wis., three blocks from the court-house. The gage is a plain staff, graduated to feet and tenths. It is fastened to the mill abutment, and is read twice daily by A. F. Lueck. The channel is straight both above and below the station. The right bank is high and the left bank is low. The river very seldom overflows its banks. The bed of the river is rocky and gravelly. The bench mark is a cross, cut in the seat of the abutment nearest to the city. Elevation, 1,000. The initial point of sounding is a nail in the footboard on the left bank of the bridge. Elevation of zero of gage is 983.75.

The following discharge measurements were made during 1902:

November 17: Gage height, 7.6 feet; discharge, 9,015 second-feet.
December 10: Gage height, 3.8 feet; discharge, 1,394 second-feet.

Daily gage height, in feet, of Wisconsin River at Merrill, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
10	.....	4.00	18	2.50	3.90	26	0.55	3.95
11	.....	3.95	19	2.50	3.85	27	.15	3.90
12	.....	4.00	20	1.90	4.05	28	.10	3.85
13	.....	4.00	21	1.85	3.80	29	.10	3.70
14	.....	3.85	22	1.55	3.80	30	.....	3.70
15	.....	3.65	23	1.50	3.75	31	.....	3.65
16	3.55	3.85	24	.90	3.85			
17	3.35	3.85	25	1.10	4.05			

ROCK RIVER DRAINAGE BASIN.

Rock River rises in the northern part of Dodge County, Wis. It flows southwest across Jefferson and Rock counties to the Illinois border; thence it flows across the northwestern portion of Illinois, emptying into the Mississippi a little below Rock Island. Its principal tributary is Catfish River, which rises in Lake Mendota and enters the Black near Jamestown, Wis. The United States Geological Survey maintains a river station on Catfiish River at Madison, and gage heights of Lake Mendota are also taken at the same place.

CATFISH RIVER AT MADISON, WIS.

This station was established December 18, 1902, by L. R. Stockman. The gage is located on the lower side of the Main Street bridge. An additional gage is maintained a few blocks away at the outlet of Lake Mendota, in order to keep a record of its water surface. Both

gages are plain staffs, graduated to feet and tenths. That on the bridge is nailed to the middle pier. Both gages are read once daily by James Mackin. The channel is straight both above and below the gaging station for over 1,000 feet, and the river is confined to its banks.

Bench mark No. 1, elevation assumed 1,000 feet, water table at the northwest corner of Nievuhr's saloon. Bench mark No. 2, elevation 1,004.46 feet, water table at the west corner of Hausmann's malt house. The 17-foot mark on gage at Main Street bridge has an elevation of 992.15 feet. The 16-foot mark on gage in Lake Mendota has an elevation of 997.27 feet, or 7.19 feet below bench mark No. 2. The 16-foot mark at the dam is 6.12 feet above the 16-foot mark of Main street gage.

The following discharge measurement was made in 1902:

December 18: Gage height, 13.9 feet; discharge, 60 second-feet.

Daily gage height, in feet, of Catfish River at Madison, Wis.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1902.		1902.		1902.		1902.	
18	13.9	22	13.9	26	14.3	30	14.3
19	13.9	23	14.0	27	14.3	31	14.3
20	13.9	24	14.1	28	14.3		
21	13.9	25	14.1	29	14.3		

ILLINOIS RIVER DRAINAGE BASIN.

Illinois River is formed by the Desplaines and Kankakee rivers, which unite about 4 miles below the point where Dupage River enters the Desplaines. The principal tributaries to these rivers are Vermilion River, which enters the Illinois proper a short distance below Lasalle; Sangamon River; Dupage River, which enters the Desplaines below Joliet; Mazon River, which enters the Illinois near Morris, and Fox River. In the latter part of 1902 M. O. Leighton visited this section in company with E. H. Heilbron, an engineer of the Chicago sanitary district. Mr. Heilbron was afterwards appointed resident hydrographer, and several stations were established, but on account of the closing of the rivers by ice soon after, few gage heights and discharge measurements were obtained during 1902. The following list gives the stations at which during 1903 measurements will be made. The descriptions of the following stations will be found on the following pages: Illinois River at Peoria, Illinois River at Lasalle, Illinois River at Ottawa, Fox River at Ottawa, Illinois River near Seneca, Illinois River near Minooka, Desplaines River near Channahon, Desplaines River above mouth of Jackson Creek near Channahon.

ILLINOIS RIVER NEAR PEORIA, ILL.

This station was originally established by Jacob Harmon. It was reestablished March 10, 1903, by E. H. Heilbron. It is located on the Peoria and Pekin Union Railroad bridge over the Illinois River, 1½ miles southwest of Peoria, Ill., and can be reached by street cars. The gage is a plain staff graduated to feet and tenths and fastened to the central pier of the bridge. It is read twice daily by the superintendent of the bridge, William Carrothers. The measurements are taken from the bridge, and the initial point for sounding is on the right bank. The river is straight for 3,000 feet above and 2,000 feet below the station. The right bank is high, and the railroad embankment is along this shore. The left bank is low and liable to overflow. The bed of the stream is composed of gravel. The bench mark is the southwest corner of the top stone of the west abutment of the bridge; elevation, 126.8 feet (approximately) below the Chicago datum. The gage at this point has for its zero a point 153.814 feet below the Chicago city datum. The gage reads up from this point, and in order to obtain the height of the river, referred to the Chicago datum, it is necessary to subtract the gage reading from 153.814 feet.

ILLINOIS RIVER AT LASALLE, ILL.

This station was established November 23, 1902, by E. H. Heilbron. It is located at the highway bridge at Shipping Sport, 1½ miles southeast of the Chicago, Rock Island and Pacific Railroad depot, Lasalle, Ill. The gage is a plain staff graduated to feet and tenths, and fastened to the southwest corner of the south pier of the bridge. The observer is James Desper, who reads the gage twice daily. The gagings are taken from the bridge, and the initial point for sounding is on the left bank. The channel is straight for a thousand feet above the station and slightly curved for a thousand feet below the station. The right bank is low and is overflowed at extreme high water. The left bank is high. The bed of the stream is composed of gravel. The Big and Little Vermilion rivers enter the Illinois just above this station. Bench mark No. 1 is at the east end of the north abutment on the second stone step from the east wing wall. It is a square marked "U. S." cut in the stone. Elevation, 114.704 feet below the Chicago datum. Bench mark No. 2 is at the east end of the south pier and is a square marked "U. S." cut in the stone. Elevation, 113.243 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

ILLINOIS RIVER AT OTTAWA, ILL.

This station is located at the Chicago, Burlington and Quincy Railroad bridge at Ottawa, Ill., below the mouth of Fox River. It was

established November 11, 1902, by E. H. Heilbron. The gage is a plain staff graduated to feet and tenths, and fastened to the center pier of the bridge, and is read twice daily by D. C. Woods. The channel is straight for a thousand feet above and below the station. The banks of the river are made up of the railroad embankment. The bed of the stream is composed of gravel. The bench mark is "U. O S." cut in the east point of the north pier of the Chicago, Burlington and Quincy Railroad bridge. Elevation, 48.638 feet above the Hennepin datum, and 103.156 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

FOX RIVER AT OTTAWA, ILL.

This station was established November 10, 1902, by E. H. Heilbron. It is located at the Main street highway bridge over Fox River at Ottawa, Ill. The gage is a plain staff fastened to the abutment of the bridge, graduated to feet and tenths, and is read twice daily by D. C. Woods. The measurements are taken from the bridge. The channel is straight for 300 feet above and 600 feet below the station. The banks are both high. The bed of the stream is rock and gravel. The bench mark is the top step of the east concrete abutment of the street railway bridge over Fox River at Main street, Ottawa, Ill. It is on the south wing wall at the south end of the parapet wall. Elevation, 99.940 feet below the Chicago city datum, and 51.854 feet above the Hennepin datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

ILLINOIS RIVER NEAR SENECA, ILL.

This station was established November 9, 1902, by E. H. Heilbron. It is located at the Kansas and Southern Railroad bridge, 2 miles from Seneca, Ill. The gage is a vertical staff graduated to feet and tenths and fastened to the center pier of the bridge. It is read twice daily by Augusta Ebeling. The measurements are taken from the bridge. The initial point for sounding is on the left bank. The channel is straight both above and below the station. Both banks of the stream are high. The bed of the stream is composed of gravel. The bench mark is a cut in the southwest corner of the south abutment of the Kansas and Southern Railroad bridge marked ⊙ S. D. B. M. Elevation, 77.220 feet below the Chicago city datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

This station was established to show the discharge of the Mazon River, which enters the Illinois a short distance above the station.

ILLINOIS RIVER NEAR MINOOKA, ILL.

This station was established November 7, 1902, by E. H. Heilbron. It is located at the Elgin, Joliet and Eastern Railroad bridge, which crosses the river a short distance below the Kankakee cut-off and 5 miles south of Minooka, Ill. The gage is a plain staff fastened to the center pier of the bridge and graduated to feet and tenths. It is read twice daily by Jesse A. Lyons. The measurements are taken from a cable and boat. The initial point for sounding is on the left bank. The channel is straight for 1,000 feet above the station and 2,000 feet below. The right bank is low and liable to overflow. The left bank is high. The bed of the stream is gravel. The bench mark is a cut in the stone on the south abutment of the Elgin, Joliet and Eastern Railroad bridge. It is marked S. D. ⊡ P. B. M. Its elevation is 85.030 feet above the Hennepin datum and 66.764 feet below the Chicago city datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

This station was established to determine the flow of Kankakee River.

DESPLAINES RIVER ABOVE THE MOUTH OF KANKAKEE RIVER, NEAR CHANNAHON, ILL.

This station was established October 24, 1902, by E. H. Heilbron. It is located just above the mouth of the Kankakee cut-off, and 2 miles below the mouth of Dupage River, near Channahon, Ill. The gage is a plain staff graduated to feet and tenths and nailed to a tree. It is read twice daily by E. A. Himes. The measurements are taken from a cable and boat. The initial point for sounding is on the left bank. The channel is straight for a thousand feet above the station and slightly curved for a thousand feet below. The right bank is high and rocky, and the I. and M. Canal runs along the bank. The left bank is high, and the Kankakee cut-off enters the river just below the gaging station. The bed of the stream is gravel. Bench mark No. 1 is a nail driven into the north side of an elm tree about 2 inches in diameter, on the Illinois and Michigan Canal towpath, 150 feet north of the Kankakee cut-off. Elevation, 81.501 feet above the Hennepin datum and 70.293 feet below the Chicago city datum. Bench mark No. 2 is a nail in the east root of an elm tree on the east bank of Desplaines River, 50 feet east of the water edge and 200 feet north of the Kankakee cut-off, opposite the point where the I. and M. Canal and Desplaines River are separated. Elevation, 74.204 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum.

This station was established in order to determine the flow of Dupage River.

DESPLAINES RIVER ABOVE THE MOUTH OF JACKSON CREEK, NEAR CHANNAHON, ILL.

This station was established October 23, 1902, by E. H. Heilbron. It is located just above the mouth of Jackson Creek, 2½ miles southwest of Millsdale, Ill. The gage is a vertical staff graduated to feet and tenths, and is read daily by Ruth Alexander. The measurements are taken from a cable and boat. The initial point for sounding is a red hub, driven in the ground on the left bank near the end of the cable. The channel is straight for about 3,000 feet both above and below the station. Both banks of the stream are low and liable to overflow, but a few feet from the top of the banks on either side are high ridges, which never overflow. Measurements can be made at all stages. The bed of the stream is gravel. The bench mark is the top of a red-oak hub (the initial point for sounding) driven in the bluff between Jackson Creek and the south bank of the Desplaines River. It is about 300 feet west of the west line of sec. 15, T. 37 N., R. 9 E., third principal meridian, and is on the farm owned by George Alexander. Elevation, 64.262 feet below the Chicago datum. The gage is set with its zero at the same elevation as the zero of the Chicago datum, thus giving directly the elevation of the river surface below this datum. This station was located to give the discharge of the upper Desplaines River.

WABASH RIVER DRAINAGE BASIN.

The drainage basin of the Wabash embraces an area of about 33,000 square miles, distributed as follows: In Ohio, 400 square miles; in Indiana, 24,350 square miles; in Illinois, 8,250 square miles. It drains, therefore, slightly more than two-thirds of Indiana, the area of the State being 35,910 square miles. Of the portion in Indiana, about one-half is embraced in the drainage areas of the East and West White rivers. By including these drainage areas with the Wabash, the entire basin has a nearly symmetrical, broadly ovate form. Not including the White River system, the Wabash Basin is an unsymmetrical, elongated tract, curving around White River.

The length of the valley occupied by the Wabash is about 450 miles, but the length of the stream is fully 500 miles, for the river in its lower course makes several oxbow curves within the valley. The source of the river is about 1,000 feet above tide, while its mouth at low water is but 311 feet. The average fall, if we estimate the stream to have a length of 500 miles, is therefore about 16.5 inches per mile. The rate of descent is far from uniform, being much more rapid in the upper portion than in the lower. There are also many rapids, separated by pools or sluggish portions of the stream. The elevation of the stream is accurately determined at many points, but in the absence of a careful measurement of the length of the stream the rate of fall

is only approximately known. The section above the point where the river enters the old lake outlet, estimated to have a length of 100 miles, has a fall of about 300 feet, or 3 feet per mile. Railway levels and canal surveys at the point where the river joins the old lake outlet show its elevation to be nearly 700 feet above sea level, the altitudes reported varying between 696 and 699 feet.

The following table gives the elevation and fall at various points in this basin:

Tables of altitudes and distances along Wabash River.

Location.	Estimated distance.	Altitude.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Source	0.0	1,000.0	0.00
Huntington	100.0	699.0	33.00
Mouth of Salamonie River	15.0	667.0	25.56
Mouth of Mississinewa River	20.0	633.0	20.40
Logansport	20.0	583.0	30.00
Lafayette	50.0	506.0	18.48
Attica	25.0	487.0	9.12
Covington	20.0	470.0	10.20
Terre Haute	55.0	447.7	4.80
State line	14.6	440.6	5.80
Hutsonville, Ill	29.0	424.6	6.60
Vincennes	46.4	398.8	6.60
Mouth of White River	32.5	376.5	8.30
Grayville, Ill	28.0	365.0	5.00
Mouth of Little Wabash	46.0	323.0	11.00
Mouth of Wabash River	16.0	311.0	9.00

During 1902 the United States Geological Survey maintained stations in this basin at Terre Haute and at Lafayette, Ind.

WABASH RIVER AT TERRE HAUTE, IND.

Gage heights of the Wabash River have been observed at the Terre Haute water works since August 2, 1902, by D. M. Raubarger, as shown in the following table:

Daily gage height, in feet, of Wabash River at Terre Haute, Ind.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1	.....	0.60	5.00	1.00	4.10	17	2.65	0.30	3.45	3.35	8.50
2	.....	.55	5.25	1.00	4.70	18	2.60	.40	2.55	3.14	9.15
3	5.20	.50	5.00	1.00	6.40	19	2.30	.35	2.80	4.40	9.55
4	5.15	.50	5.85	1.00	7.40	20	2.65	.40	2.50	5.15	10.40
5	4.20	.45	6.90	1.20	7.60	21	2.80	.35	2.65	5.80	12.80
6	5.05	.70	7.35	1.50	8.90	22	2.85	.30	2.45	5.20	14.35
7	4.45	.90	7.65	1.90	8.40	23	2.50	.30	2.80	4.85	15.30
8	4.05	.75	8.65	2.60	6.65	24	2.15	.40	2.55	4.25	15.65
9	3.75	.50	8.00	3.20	5.85	25	1.80	2.80	2.10	3.90	15.10
10	3.05	.30	6.70	3.25	4.95	26	1.55	3.80	1.90	3.45	16.00
11	2.90	.20	5.70	3.30	4.65	27	1.20	2.80	1.60	3.30	15.35
12	2.50	.25	4.45	4.05	5.60	28	1.50	4.50	1.60	2.50	14.50
13	2.30	.10	3.50	4.00	5.75	29	.95	4.80	1.45	2.80	9.30
14	2.30	.45	3.45	4.00	6.30	30	.80	3.60	1.35	5.40	7.40
15	2.40	.35	3.50	3.75	5.70	31	.80	.....	1.15	.....	6.80
16	2.70	.40	4.10	3.45	8.40						

WABASH RIVER AT LAFAYETTE, IND.

This station was established May 2, 1901, by George E. Waesche, and is carried on in connection with the Civil Engineering College of Purdue University. It is about one-half mile above Brown street bridge, Lafayette, Ind., and about one-fourth mile below the West Lafayette Pumping Station. The gage is on the left bank and is in two parts. The lower portion is a 2-inch by 4-inch white pine plank, graduated to feet and hundredths, extending down into an 18-inch sewer pipe, into which the water from the river is admitted. The upper portion of the gage is graduated to feet and tenths and is nailed to a large sycamore tree.

The measurements are made by means of a boat held in place by a wire cable. The cable is adjustable so that it can be placed at any height above the surface of the water. The initial point for sounding is a gas-pipe plug set firmly in the west bank 25 feet east of the pole which supports the west end of the cable. The channel is straight both above and below the station, and is unobstructed except for a small sand bar at the mouth of a small stream which enters the river 1,500 feet above the station. The current is uniform. The banks are low and overflow at high water. The bed of the stream is a gravelly mixture, comparatively smooth, and slightly shifting. The bench mark is the head of a brass rod embedded in a block of concrete placed about 150 feet upstream from the gage. Its elevation is 515.046 feet above sea level and 14.31 feet above the zero of the gage. The gage is read by the students of Purdue University.

List of discharge measurements of Wabash River at Lafayette, Ind.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Second-feet.*
May 9	S. A. Coffin and H. B. Holman	2.70	3,850
May 15	.....do	2.13	2,832
May 20	.....do	1.63	2,212
Sept. 28	G. H. Cook and L. W. Dinsmore	.36	530
Oct. 4	.....do	.31	497
Nov. 9	.....do	.75	887
1902.			
Mar. 22	G. H. Cook and L. W. Dinsmore	3.50	5,244
Mar. 24	.....do	1.40	1,822
May 3	.....do	2.00	2,496
June 4	Geo. E. Waesche	7.35	11,692
June 4	.....do	7.35	12,160
July 26	.....do	3.12	3,953
July 26	.....do	3.12	4,089

Daily gage height, in feet, of Wabash River at Lafayette, Ind.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.											
1	.....	1.52	5.30	2.90	6.10	2.05	0.32	0.56	0.33	0.84	0.87
2	1.65	1.72	5.35	2.65	5.20	1.80	.30	.55	.31	.82	.88
3	2.10	3.10	4.85	2.50	4.22	1.55	.29	.54	.31	.81	.88
4	2.18	4.25	5.37	2.46	3.20	1.50	.28	.55	.31	.80	.87
5	1.90	4.90	4.70	2.30	3.05	1.55	.27	.54	.31	.81	.85
6	1.80	4.70	3.88	2.16	3.47	1.52	.28	.54	.34	.83	.85
7	1.78	4.45	3.47	2.25	3.44	1.40	.28	.55	.38	.82	.85
8	1.80	5.15	3.67	2.30	3.02	1.25	.27	.56	.40	.79	.93
9	1.80	5.92	3.75	2.40	2.73	1.12	.26	.57	.41	.77	.97
10	1.78	11.70	3.45	2.76	2.45	1.02	.26	.57	.43	.78	1.10
11	1.77	16.65	3.22	2.78	2.12	.98	.27	.57	.45	.85	1.20
12	1.67	17.22	3.00	2.82	1.97	.97	.26	.58	.90	.87	1.30
13	1.62	16.15	2.82	2.60	1.90	.90	.25	.59	1.85	.88	2.25
14	1.61	14.64	2.72	2.30	1.75	.85	.25	.56	2.25	.86	4.20
15	1.60	13.00	2.85	2.20	1.58	.77	.24	.50	3.65	.88	5.40
16	1.60	11.20	2.87	2.05	1.50	.73	.25	.50	3.31	.88	5.10
17	1.68	9.51	2.87	1.83	1.48	.71	.25	.49	2.84	.88	6.62
18	2.13	9.65	3.50	1.72	1.38	.69	.24	.46	2.43	.86	6.80
19	2.15	8.85	6.30	1.68	1.47	.70	.25	.43	2.03	.84	6.26
20	2.58	8.55	8.30	1.70	1.78	.69	.26	.44	1.78	.83	6.17
21	2.50	8.87	8.15	1.68	2.68	.61	.27	.45	1.57	.85	6.15
22	2.10	7.70	7.40	1.70	3.55	.56	.27	.46	1.40	.86	6.15
23	2.27	6.70	5.45	1.77	3.40	.52	.28	.45	1.28	.88	6.13
24	2.20	7.00	5.21	1.83	2.97	.48	.26	.43	1.18	.88	6.07
25	2.04	10.50	5.80	2.04	2.60	.46	.30	.41	1.11	.88	6.05
26	1.82	12.95	5.50	2.60	2.40	.41	.78	.41	1.04	.89	6.04
27	1.70	11.40	4.80	2.63	2.41	.39	.73	.40	1.00	.90	5.98
28	1.61	9.25	4.20	2.58	2.53	.39	.70	.38	.96	.89	5.95
29	.....	7.32	3.80	4.65	2.65	.39	.68	.36	.93	.88	5.93
30	.....	6.06	3.30	7.80	2.32	.37	.55	.35	.91	.87	5.80
31	.....	5.10	.....	7.10	.....	.35	.56	.....	.88	.....	5.65

Daily gage height, in feet, of Wabash River at Lafayette, Ind.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.40	.....	.....	7.50	1.85	1.60	17.85	5.80	1.20	5.60	1.91	3.25
2	5.30	.....	.....	5.95	1.95	1.75	17.35	5.92	1.37	5.28	1.87	4.50
3	4.65	.....	.....	5.05	1.85	3.65	16.35	4.40	1.62	4.58	1.83	6.25
4	3.65	.....	.....	4.20	2.10	7.05	15.60	3.60	1.60	5.80	1.78	8.00
5	3.50	.....	.....	3.90	2.15	6.93	13.60	3.00	1.38	7.15	1.79	7.70
6	3.15	.....	.....	3.75	2.35	6.10	11.10	2.75	1.24	7.60	2.12	6.04
7	3.00	.....	.....	3.60	2.60	5.73	9.10	2.55	1.12	6.72	2.78	5.20
8	2.85	.....	.....	3.50	2.50	6.95	8.70	2.40	1.13	5.65	3.00	4.66
9	2.75	.....	.....	3.30	2.45	8.37	7.50	2.22	1.10	4.81	2.76	3.92
10	2.65	.....	.....	3.00	2.35	6.55	6.75	2.10	1.08	4.25	2.53	3.45
11	2.55	.....	.....	2.85	2.10	5.55	5.80	2.05	1.09	4.12	2.75	3.56
12	2.00	.....	.....	2.65	1.90	5.00	5.00	1.88	1.14	3.72	3.19	3.74
13	1.80	.....	.....	2.40	1.80	4.40	4.34	1.75	1.16	3.73	3.33	3.85
14	1.80	.....	.....	2.20	1.70	4.60	3.87	1.72	1.24	4.50	3.15	3.65
15	1.80	.....	.....	2.05	.....	5.05	3.60	1.70	1.28	4.12	3.08	3.75
16	1.85	.....	.....	1.90	.....	5.20	2.95	1.54	1.36	3.38	3.04	4.90
17	1.80	.....	.....	1.80	.....	4.45	2.65	1.40	1.18	3.08	3.18	7.70
18	1.80	.....	.....	1.75	1.56	3.57	2.60	1.30	1.14	2.85	4.20	9.12
19	1.75	.....	5.00	1.70	.....	3.00	2.70	1.21	1.10	2.82	5.68	8.35
20	1.75	.....	4.50	1.60	.....	2.50	4.80	1.67	1.05	3.20	5.53	7.95
21	1.65	.....	3.70	1.60	1.75	2.05	5.50	1.92	1.02	3.24	5.80	10.70
22	1.60	.....	3.50	1.60	1.90	1.87	5.00	1.80	1.05	3.08	4.30	14.38
23	1.60	.....	3.30	1.45	2.00	1.94	4.35	1.60	1.32	2.77	3.82	15.46
24	1.60	.....	2.95	1.40	.....	1.78	4.20	1.40	2.02	2.50	3.37	14.40
25	.....	.....	2.75	1.40	.....	2.00	3.65	1.31	3.15	2.30	3.07	11.75
26	.....	.....	2.50	1.38	.....	2.12	3.08	1.25	4.92	2.22	2.95	9.14
27	.....	.....	2.40	1.40	.....	2.00	2.80	1.20	4.75	2.18	2.84	7.90
28	.....	.....	2.60	1.45	.....	4.80	3.20	1.20	5.45	2.15	2.81	6.65
29	.....	.....	2.87	1.75	.....	12.10	3.55	1.17	5.45	1.98	2.90	6.08
30	.....	.....	4.55	1.95	.....	16.20	3.60	1.12	5.25	1.91	3.12	5.37
31	.....	.....	7.90	.....	.....	.....	3.50	1.12	.....	1.91	.....	4.47

Rating table for Wabash River at Lafayette, Ind., for 1901 and 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.00	260	1.75	2,160	3.50	5,080	6.00	9,780
.25	430	2.00	2,550	3.75	5,560	7.00	11,660
.50	645	2.25	2,940	4.00	6,020	8.00	13,540
.75	880	2.50	3,340	4.25	6,490	9.00	15,420
1.00	1,170	2.75	3,760	4.50	6,960		
1.25	1,490	3.00	4,180	4.75	7,430		
1.50	1,810	3.25	4,620	5.00	7,900		

Estimated monthly discharge of Wabash River at Lafayette, Ind.

[Drainage area, 7,314 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
January [a]					
February 2 to 28	3,490	1,950	2,322	0.32	0.33
March	30,850	1,840	14,607	2.00	2.31
April	14,110	3,710	7,031	.96	1.07
May	13,170	2,060	3,686	.50	.58
June	9,970	1,650	3,777	.52	.58
July	2,630	510	1,098	.15	.17
August	930	430	518	.07	.08
September	730	510	638	.09	.10
October	5,370	480	1,571	.21	.24
November	1,060	910	1,003	.14	.16
December	11,280	1,000	6,121	.84	.97
1902.					
January 1 to 24 [a]			3,596	0.49	0.44
February [a]					
March 19 to 31 [a]			5,567	.76	.37
April	12,600	1,650	3,771	.52	.58
May 1 to 14; 18, 21, 22, 23 [a]			2,632	.36	.24
June	28,950	2,230	7,708	1.05	1.17
July	32,050	3,510	10,924	1.49	1.72
August	9,620	1,320	2,882	.39	.45
September	8,740	1,190	2,706	.37	.41
October	12,780	2,410	5,796	.79	.91
November	9,410	2,210	4,530	.62	.69
December	27,550	4,620	11,587	1.58	1.82

[a] Missing record due to ice.

MUSKINGUM RIVER DRAINAGE BASIN.

Muskingum River is formed by the junction of Walhonding and Tuscarawas rivers in the east central part of Ohio; flows south, and enters Ohio River at Marietta, Ohio. In this drainage basin the United States Geological Survey has two stations—one on Jonathan Creek at Powells, Ohio, and the other on Licking River at Pleasant Valley, Ohio. These two streams enter the main river near Zanesville. The hydrographic work during 1902 was under the direction of the late B. H. Flynn.

JONATHAN CREEK AT POWELLS, OHIO.

Jonathan Creek flows into Muskingum River a short distance below Zanesville, Ohio.

The gaging station at Powells was established November 15, 1902, by Benjamin H. Flynn. It is located on the railroad bridge one-fourth of a mile north of the railroad station. The gage is a plain staff graduated to feet and tenths. The channel is straight both above and below the station. The river is confined to its channel by the railroad embankments. The bed of the stream is rocky. Low-water discharge measurements are made by wading; high-water measurements, from the bridge. The bench mark is a cut on the downstream side of the wing wall of the left abutment; elevation, 7 feet above the zero of the gage.

The following discharge measurements were made during 1902:

November 15: Gage height, 0.80 feet; discharge, 19 second-feet.
December 12: Gage height, 2.18 feet; discharge, 702 second-feet.

Daily gage height, in feet, of Jonathan Creek at Powells, Ohio.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1	.....	0.90	12	.....	2.70	23	1.00	1.40
2	.....	.90	13	.....	2.20	24	.90	1.00
3	.....	1.70	14	.....	1.80	25	1.00	.90
4	.....	1.00	15	.....	1.30	26	1.00	.90
5	.....	1.00	16	0.80	8.00	27	1.00	1.40
6	.....	1.00	17	.80	2.70	28	.90	1.40
7	.....	.90	18	1.30	1.80	29	.90	1.10
8	.....	.90	19	.95	1.60	30	.90	1.00
9	.....	.90	20	.90	1.30	31	.....	1.40
10	.....	.90	21	.85	1.60			
11	.....	1.00	22	.95	1.70			

LICKING RIVER AT PLEASANT VALLEY, OHIO.

Licking River flows into the Muskingum at Zanesville.

The gaging station at Pleasant Valley was established November 14, 1902, by Benjamin H. Flynn. It is located at the highway bridge 300 feet north of the railroad station at Pleasant Valley, Ohio. The lower part of the gage is inclined and spiked to a post driven into the bank. The upper part is vertical and spiked to a tree. It is graduated to read direct to feet and tenths. The channel is straight for 200 feet above and 300 feet below the station. The banks are high and not liable to overflow except in extreme floods. The bed of the stream is gravel and clay. The low-water measurements are made by wading and the high-water measurements from the highway bridge. There are three bench marks. The first is a copper nail on the gage tree; elevation, 13 feet above the zero of the gage. The second is some copper nails on a walnut tree 200 feet west of the gage; elevation, 15 to 17 feet above the zero of the gage. The third consists of copper nails on a

telephone pole north of the tree; elevation, 13 to 16 feet above the zero of the gage. The initial point for sounding is a cross on the top stone of the down stream side of the right abutment of the highway bridge.

The following discharge measurements were made during 1902:

November 14: Gage height, 1.58 feet; discharge, 121 second-feet.
December 13: Gage height, 5.49 feet; discharge, 2,281 second-feet.

Daily gage height, in feet, of Licking River at Pleasant Valley, Ohio.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		2.50	12		7.00	23	2.00	3.80
2		2.30	13		5.70	24	2.00	4.00
3		2.80	14	1.60	5.60	25	2.10	3.90
4		4.00	15	1.60	4.50	26	2.40	3.00
5		3.30	16	1.50	9.60	27	2.70	3.00
6		3.00	17	1.50	11.40	28	2.90	2.70
7		2.70	18	3.70	6.50	29	2.80	2.70
8		2.70	19	3.30	4.90	30	2.50	2.60
9		2.60	20	2.60	4.00	31		2.60
10		2.60	21	2.30	3.90			
11		2.50	22	2.10	4.20			

MONONGAHELA RIVER DRAINAGE BASIN.

Monongahela River rises in the central part of West Virginia and, flowing north, crosses into Pennsylvania. At Pittsburg it unites with the Allegheny, forming the Ohio. Its principal tributaries are the Youghiogheny, which flows into it about 15 miles above Pittsburg, and the Cheat, which joins it just north of the Pennsylvania line. Under the direction of E. G. Paul, the United States Geological Survey is maintaining a station on the Youghiogheny, at Friendsville, Md., and one on the Cheat, at Uneva, near Morgantown, W. Va.

YOUGHIOGHENY RIVER AT FRIENDSVILLE, MD.

This river rises in Garrett County, Md., and flows in a northwesterly direction into Pennsylvania, where it empties into Monongahela River 15 miles above Pittsburg. Its source is on the western slope of the Allegheny Mountains, at an elevation of about 2,900 feet. The average fall of the stream for 19 miles above its mouth is about 2 feet per mile, but above this point it soon increases to an average fall of nearly 5 feet per mile. The bank height above low water ranges between 15 and 28 feet, and the average width between banks from the mouth to West Newton, Pa., is 546 feet. The following heights of the high water of February, 1897, above low-water stage, at various points in Pennsylvania, were furnished by George M. Lehman: Whikett, 13 feet; Jacobs Creek, 10 feet; Smithton, 14 feet; Port Royal, 17 feet; Snyder, 16 feet; West Newton, 20 feet; Suterville, 22 feet; Buena Vista, 26.5 feet; Coulterville, 28.5 feet; Boston, 29 feet; McKeesport, 28.5 feet.

A measurement of Youghiogheny River was made October 13, 1892, with surface floats, at Ohio Pyle, Pa., by Kenneth Allen, in connection with an investigation of a water supply for the works of the H. C. Frick Coke Company. It was during a period of extreme drought, and the discharge was found to be 106 second-feet.

The station at Friendsville, Md., was established by E. G. Paul, on August 17, 1898. Measurements are made from the iron highway bridge connecting the east and the west portion of the village. The wire gage is 20 feet from zero to the end of the weight, and is referred to a scale board 14 feet long, graduated to feet and tenths. The channel is straight for several hundred feet above and below the bridge. The bed is rocky and the banks are high and not subject to overflow. The observer is J. H. Cuppet, a merchant residing within a short distance of the gage.

The following discharge measurement was made in 1902 by R. B. Hayes:

August 22: Gage height, 4.4 feet; discharge, 208 second-feet.

Daily gage height, in feet, of Youghiogheny River at Friendsville, Md.

Day	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.00	5.60	10.02	5.30	4.90	5.00	6.80	4.50	3.90	4.20	4.20	5.80
2	5.80	5.40	8.80	5.40	4.90	4.80	6.70	4.60	3.90	4.20	4.20	5.80
3	5.40	5.20	8.10	5.60	4.80	4.70	6.70	4.90	3.90	4.30	4.20	5.90
4	5.40	5.10	6.30	5.70	4.70	4.60	6.60	4.80	3.90	4.40	4.10	5.90
5	5.30	5.00	6.10	6.40	4.70	4.50	6.00	4.50	3.80	4.30	4.10	5.80
6	5.20	5.00	5.90	6.40	4.60	4.50	5.10	4.40	3.80	4.30	4.10	5.80
7	5.00	5.00	5.70	6.50	4.60	4.50	4.80	4.30	3.90	4.30	4.20	5.90
8	5.00	5.00	5.50	6.60	4.60	4.50	4.60	4.30	3.90	4.20	4.20	5.70
9	4.90	5.00	5.40	6.60	4.60	4.50	4.80	4.20	3.90	4.20	4.20	5.60
10	4.80	5.00	5.60	6.50	4.60	4.40	5.00	4.20	3.90	4.40	4.20	5.60
11	4.80	5.00	6.20	7.40	4.50	4.30	4.90	4.20	3.90	4.40	4.20	5.50
12	4.80	5.00	7.10	8.20	4.50	4.30	4.70	4.20	3.90	5.30	4.20	8.50
13	4.80	5.00	8.50	7.80	4.50	4.50	4.50	4.10	3.80	5.30	4.20	7.90
14	4.80	5.00	8.10	7.40	4.50	4.50	4.40	4.10	3.80	5.00	4.20	7.50
15	4.70	5.00	7.80	7.10	4.40	4.60	4.30	4.10	3.80	5.00	4.20	7.30
16	4.70	5.00	7.30	6.70	4.40	4.70	4.30	4.10	3.80	4.70	4.20	8.20
17	4.70	5.00	6.90	6.80	4.40	4.70	4.30	4.10	3.80	4.60	4.20	8.60
18	4.80	5.00	6.40	6.80	4.50	4.70	4.50	4.10	3.80	4.60	4.20	8.30
19	4.90	5.00	6.10	6.60	4.80	4.60	4.70	4.20	3.80	4.50	4.20	8.00
20	5.00	5.00	5.90	6.30	4.90	4.60	4.80	4.30	3.80	4.50	4.10	7.30
21	5.00	5.00	5.60	5.80	4.70	4.60	4.70	4.40	3.90	4.40	4.10	6.50
22	5.00	5.00	5.50	5.40	4.80	4.50	4.60	4.40	3.90	4.40	4.10	6.10
23	5.00	5.00	5.40	5.20	5.00	4.50	4.40	4.40	3.90	4.20	4.30	6.10
24	5.40	5.00	5.30	5.00	5.30	4.60	4.20	4.30	3.90	4.20	4.50	6.00
25	5.60	5.00	5.20	4.80	5.60	4.80	4.20	4.20	4.00	4.10	5.40	6.00
26	7.10	7.40	5.10	4.70	5.70	4.80	4.20	4.00	4.00	4.10	6.20	5.90
27	7.30	6.50	5.10	4.70	5.80	4.90	4.40	4.00	4.00	4.20	6.00	5.80
28	6.90	7.30	5.00	4.70	5.80	4.70	4.50	3.90	4.00	4.40	6.00	5.50
29	6.30	.....	5.10	4.80	5.30	4.90	4.60	3.90	4.00	4.40	6.00	5.30
30	6.00	.....	5.10	4.90	5.30	5.70	4.50	3.90	4.00	4.50	6.00	5.20
31	5.80	.....	5.10	.....	5.20	.....	4.50	3.90	.....	4.30	.....	5.10

Rating table for Youghiogheny River at Friendsville, Md., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.6	12	4.6	340	5.6	1,150	7.5	3,310
3.8	45	4.8	464	5.8	1,372	8.0	3,880
4.0	90	5.0	600	6.0	1,600	9.0	5,020
4.2	150	5.2	770	6.5	2,170		
4.4	230	5.4	955	7.0	2,740		

Estimated monthly discharge of Youghiogheny River at Friendsville, Md.

[Drainage area, 295 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	3,082	400	992	3.36	3.87
February	3,196	600	879	2.98	3.10
March	6,183	600	1,970	6.68	7.70
April	4,108	400	1,742	5.91	6.59
May	1,372	230	551	1.87	2.16
June	1,260	185	382	1.29	1.44
July	2,512	150	638	2.16	2.49
August	530	65	181	.61	.70
September	90	45	63	.21	.23
October	862	120	280	.95	1.10
November	1,828	120	426	1.44	1.61
December	4,564	685	2,066	7.00	8.07
The year	6,183	45	848	2.87	39.06

CHEAT RIVER NEAR MORGANTOWN, W. VA.

A cable gaging station was established July 8, 1889, by E. G. Paul, at Uneva, near Morgantown. It was found desirable, after one or two measurements, to move the cable a mile down the river to a place where a more satisfactory cross section and better facilities for making gage-height observations could be secured. An inclined timber gage was established at the present station on August 21, 1902. The present observer is Miss Anna Hastings.

The following discharge measurement was made in 1902 by E. G. Paul:

August 20: Discharge, 299 second-feet.

Daily gage height, in feet, of Cheat River near Morgantown, W. Va.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1	.....	1.70	2.80	2.50	4.65	17	.....	1.40	3.00	2.20	10.45
2	.....	1.70	4.80	2.20	4.50	18	.....	1.40	2.80	2.20	8.45
3	.....	1.70	3.65	2.20	6.15	19	.....	1.50	2.65	2.00	7.50
4	.....	1.80	3.40	2.20	6.40	20	.....	1.40	2.45	2.00	5.65
5	.....	1.65	3.40	2.05	5.35	21	1.80	1.40	2.45	2.15	4.40
6	.....	2.30	3.45	1.90	4.60	22	1.90	1.30	2.35	2.40	5.20
7	.....	2.00	3.05	2.15	4.15	23	2.60	1.30	2.20	2.35	5.50
8	.....	1.85	2.85	2.20	4.10	24	2.70	1.30	2.20	2.75	4.80
9	.....	1.70	2.60	2.40	3.95	25	3.30	1.30	2.20	4.35	4.30
10	.....	1.70	2.35	2.25	3.55	26	2.05	1.45	2.10	8.00	3.95
11	.....	1.70	2.20	2.20	5.70	27	1.90	1.70	2.20	6.60	3.45
12	.....	1.60	5.45	2.20	10.90	28	1.80	1.60	2.75	5.35	3.20
13	.....	1.60	4.95	2.20	10.50	29	1.70	2.00	2.60	4.55	3.35
14	.....	1.50	4.40	2.25	10.50	30	1.70	2.05	2.60	4.05	4.75
15	.....	1.50	3.75	2.20	8.95	31	1.70	.....	2.50	.....	4.55
16	.....	1.45	3.30	2.20	6.70						

KANAWHA RIVER DRAINAGE BASIN.

The Kanawha River flows north through West Virginia, joining the Ohio River at Point Pleasant, W. Va. In its upper course it is known as the New River, which rises in Watauga, Ashe, and Alleghany counties, N. C. The area of the latter two counties is comprised wholly within the drainage basin of the New River; their boundaries, being along the mountain ridges, form the divides between the drainage basin of this river and Yadkin River on the east and of Holston River on the west. The general direction of the river is northwesterly. At first the upper tributaries have a general northeasterly and southwesterly direction, draining narrow valleys of the Greater Appalachian Valley in Virginia. The main river cuts the Alleghany fronts just below Pearisburg, Va., and the remainder of the drainage area is confined to the State of West Virginia. For some distance the basin divide follows the State line between Virginia and West Virginia, both north and south of the point where the river pierces the Alleghany front. The basin of New River is as beautiful and picturesque a section of country as any in the eastern part of the United States. The river itself is rapid. The country on its lower courses, through which the Chesapeake and Ohio Railway passes, is noted for its scenic beauty.

The principal tributaries of the New River are Little River, which empties near Radford, Va., and the Greenbrier, which rises in the eastern part of West Virginia and joins the New at Hinton, W. Va. The following is a list of the stations maintained in this drainage basin by the United States Geological Survey, under the supervision of E. W. Myers and D. C. Humphreys: New River at Fayette, W. Va.; Greenbrier River at Alderson, W. Va.; New River at Radford, Va.; New River near Oldtown, Va.; New River (North Fork) at Weaversford, N. C.; New River (South Fork) at New River, N. C.

NEW RIVER AT FAYETTE, W. VA.

This station, established by C. C. Babb and D. C. Humphreys July 29, 1895, is located just below the mouth of Wolf Creek, on the highway bridge of one span at Fayette, W. Va. The wire gage is on the guard rail on the upper side of the bridge, about the middle of the span, the scale being graduated to feet and tenths. The gage is referred to four bench marks: First, the top of the bottom plate of the lower plate girder at the end of the first panel from the left bank, downstream side, 55.13 feet above the zero of the gage; second, the top of the lower end of the coping on the main pier, right bank, downstream side, 52.13 feet above the zero of the gage; third, the bridge seat on the right bank, downstream side, 54.58 feet above the zero of the gage; fourth, the west corner of the abutment stone by the Chesapeake and Ohio Railway station, 58.62 feet above the zero of the gage. The channel is straight above and below the station, the current is swift and without obstructions, except for immense bowlders in the bottom. The banks are high, rocky, and not subject to overflow. The bed is constant in section. The observer is M. W. Brellahan, manager of coal mine, Fayette, W. Va. The station was discontinued May 22, 1901. On August 11, 1902, it was reestablished. The zero of the new gage is at the same elevation as the zero of the old gage.

The following discharge measurements were made during 1902 by D. C. Humphreys:

July 17: Gage height, 2.26 feet; discharge, 4,032 second-feet.
August 14: Gage height, 1.10 feet; discharge, 2,022 second-feet.

Daily gage height, in feet, of New River at Fayette, W. Va.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1		0.08	0.81	1.30	4.05	17	0.80	0.05	1.50	0.59	8.96
2		.10	.56	.90	3.95	18	.60	.03	1.10	.57	9.90
3		.02	.59	.71	6.30	19	.78	.09	.40	.72	8.39
4		.00	.95	.56	6.56	20	1.15	.00	.60	1.30	6.86
5		.08	1.10	.32	6.95	21	1.35	.03	.56	2.80	5.50
6		.49	.91	.73	6.01	22	.10	.12	.50	2.22	4.80
7		1.20	4.30	.71	6.15	23	.25	.18	.20	1.65	4.68
8		.88	2.71	.70	5.52	24	.75	.19	.24	1.40	5.50
9		1.10	1.85	1.31	4.72	25	.70	.35	.29	1.50	5.00
10		.28	1.18	1.28	4.15	26	.68	.22	.25	2.47	4.38
11	1.25	.23	.75	1.12	3.67	27	.50	.29	.24	3.02	4.00
12	1.20	1.04	.81	.96	3.27	28	.28	.00	.20	5.30	2.90
13	1.10	1.69	.76	.80	4.08	29	15	1.12	.26	5.08	2.50
14	1.10	1.00	1.05	.71	7.95	30	.48	1.15	56	3.90	2.40
15	1.00	1.10	2.20	.62	8.86	31	28	.....	1.60	.....	2.30
16	.95	1.30	2.00	.60	8.90						

Rating table for New River at Fayette, W. Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0[a]	600	4.0	7,400	8.0	17,148	15.0	38,960
.2[a]	828	4.2	7,800	8.2	17,700	16.0	42,760
.4[a]	1,068	4.4	8,200	8.4	18,300	17.0	46,560
.6[a]	1,316	4.6	8,600	8.6	18,900	18.0	50,360
.8[a]	1,576	4.8	9,040	8.8	19,500	19.0	54,160
1.0	1,862	5.0	9,480	9.0	20,100	20.0	57,960
1.2	2,194	5.2	9,930	9.2	20,700	21.0	61,760
1.4	2,539	5.4	10,390	9.4	21,300	22.0	65,560
1.6	2,887	5.6	10,850	9.6	21,900	23.0	69,360
1.8	3,235	5.8	11,350	9.8	22,500	24.0	73,160
2.0	3,583	6.0	11,850	10.0	23,100	25.0	76,960
2.2	3,933	6.2	12,350	10.5	24,600	26.0	80,760
2.4	4,293	6.4	12,850	11.0	26,100	27.0	84,560
2.6	4,669	6.6	13,350	11.5	27,600	28.0	88,360
2.8	5,053	6.8	13,850	12.0	29,100	29.0	92,160
3.0	5,439	7.0	14,398	12.5	30,600	30.0	95,960
3.2	5,827	7.2	14,946	13.0	32,100	31.0	99,760
3.4	6,216	7.4	15,494	13.5	33,600	32.0	103,560
3.6	6,608	7.6	16,044	14.0	35,160	33.0	107,360
3.8	7,004	7.8	16,596	14.5	37,060	34.0	111,160

[a] Discharge below 1 foot gage height is not well determined and must be considered as approximate.

Estimated monthly discharge of New River at Fayette, W. Va.

[Drainage area, 6,200 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
August 11 to 31	.....	.....	1,536	0.25	0.20
September	3,061	600	1,224	.20	.22
October	8,000	828	1,999	.32	.37
November	10,160	948	2,893	.47	.52
December	22,800	4,111	10,972	1.77	2.04

GREENBRIER RIVER AT ALDERSON, W. VA.

This river rises on the western slope of the Allegheny Mountains, in Pocahontas County, W. Va., and flows in a southwesterly direction, emptying into New River near Hinton, Summers County, W. Va. The station was established by C. C. Babb and D. C. Humphreys, at Alderson, W. Va., 21 miles above Hinton, August 1, 1895. Greenbrier River receives many short tributaries from the Allegheny Range, and flows for the most part through a broken, hilly, and mountainous country well covered with forests. The station is located one-half mile above the mouth of Muddy Creek, on the county bridge at Alderson. The wire gage, length 28.37 feet, is in the third panel of the second span, downstream side of the bridge. This gage is referred to three bench marks: the first, on the upper end of the coping of the first pier from the left bank, 21.75 feet above the zero of the gage; the second, on the upper end of the bridge seat of the left bank abutment, 21.61 feet above the zero of the gage; the third, on the stone foundation of the water tank of the Chesapeake and Ohio Railway, 23.48 feet above the zero of the gage. A temporary bench mark has been established on the lower end of the third floor beam, in the second span from the left bank. Its elevation is 22.47 feet above the zero of the gage. The bridge consists of four spans 435 feet long. At ordinary stages the water flows in two channels, between which is an island 600 feet long and 75 feet wide. The banks are high and not subject to overflow. The bed is of rock and gravel and fairly constant. The observer is W. J. Hancock, clerk in a hardware store at Alderson, W. Va.

The following discharge measurements were made during 1902 by D. C. Humphreys:

July 17: Gage height, 1.63 feet; discharge, 211 second-feet.
August 12: Gage height, 1.46 feet; discharge, 156 second-feet.
August 12: Gage height, 1.46 feet; discharge, 154 second-feet.

Daily gage height, in feet, of Greenbrier River at Alderson, W. Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.85	5.20	11.75	4.45	2.20	2.30	2.35	1.50	1.36	1.70	1.55	2.70
2	4.05	4.80	7.00	3.85	2.22	2.18	2.30	1.50	1.33	1.60	1.55	4.05
3	3.60	5.05	5.60	3.53	2.23	2.10	2.35	1.70	1.32	1.90	1.55	3.65
4	3.30	4.00	4.50	3.30	2.24	2.05	2.38	1.60	1.35	2.00	1.60	4.25
5	3.00	3.92	3.90	4.04	2.25	2.00	2.30	1.55	1.33	1.90	1.55	3.50
6	2.58	3.00	3.45	3.87	2.25	1.92	2.00	1.53	1.32	1.70	1.53	3.35
7	2.48	2.98	3.45	4.35	2.26	1.90	2.00	1.50	1.35	1.65	1.47	3.15
8	2.53	2.88	3.45	5.45	2.23	1.85	2.05	1.50	1.32	1.55	1.47	3.05
9	2.63	2.90	4.12	5.35	2.20	1.80	2.10	1.50	1.28	1.52	1.42	2.85
10	2.55	3.13	5.77	4.80	2.15	1.78	2.15	1.50	1.25	1.52	1.43	2.85
11	2.50	2.30	5.40	5.00	2.10	1.75	2.00	1.50	1.22	1.52	1.45	2.75
12	2.35	2.35	6.05	4.67	2.05	1.73	1.93	1.50	1.22	1.55	1.45	2.45
13	2.25	2.30	7.58	4.50	2.00	1.75	1.82	1.46	1.22	1.75	1.45	3.10
14	2.15	2.33	7.76	3.15	1.98	1.78	1.80	1.42	1.25	2.12	1.45	5.15
15	2.00	2.30	5.24	3.65	1.98	1.80	1.80	1.40	1.25	2.10	1.43	4.65
16	2.15	2.15	5.45	3.40	1.90	1.83	1.77	1.40	1.28	1.95	1.43	4.50
17	2.12	2.20	7.65	3.28	1.90	1.84	1.75	1.40	1.25	1.83	1.43	5.00
18	2.10	2.15	6.00	3.05	1.92	1.85	1.75	1.40	1.25	1.80	1.44	5.10
19	2.00	2.15	4.65	2.95	1.85	1.86	1.74	1.39	1.25	1.80	1.44	4.30
20	1.95	2.10	3.90	2.90	1.85	1.97	1.74	1.38	1.20	1.75	1.45	3.50
21	2.08	2.15	3.50	2.85	2.07	1.95	1.70	1.38	1.20	1.65	1.45	3.30
22	2.00	2.15	3.25	2.77	2.05	2.00	1.68	1.36	1.20	1.55	1.45	3.00
23	2.17	2.45	3.00	2.70	2.28	2.10	1.60	1.35	1.20	1.55	1.55	3.35
24	2.05	3.10	2.95	2.65	2.15	2.16	1.55	1.35	1.20	1.55	1.60	3.20
25	1.95	7.82	2.93	2.60	2.13	2.15	1.50	1.30	1.22	1.55	1.64	3.00
26	2.10	8.42	3.03	2.50	2.85	2.08	1.50	1.30	1.20	1.55	3.24	2.80
27	6.15	6.45	2.95	2.45	3.50	1.95	1.50	1.27	1.25	1.55	3.60	2.58
28	6.95	11.53	2.85	2.30	3.08	2.85	1,50	1.25	1.75	1.55	3.45	2.30
29	4.75	.....	6.10	2.30	2.80	2.80	1.50	1.18	1.65	1.55	3.40	2.30
30	4.90	.....	7.75	2.25	2.60	2.40	1.50	1.25	1.70	1.55	2.73	2.45
31	6.60	.....	5.90	.....	2.45	.....	1.50	1.33	.....	1.55	.....	2.35

Rating table for Greenbrier River at Alderson, W. Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	60	3.0	1,900	4.8	6,180	7.5	14,000
1.4	120	3.2	2,330	5.0	6,700	8.0	15,600
1.6	220	3.4	2,770	5.2	7,220	9.0	19,000
1.8	350	3.6	3,240	5.4	7,740	10.0	22,500
2.0	505	3.8	3,720	5.6	8,300	11.0	26,500
2.2	685	4.0	4,200	5.8	8,900	12.0	31,200
2.4	920	4.2	4,680	6.0	9,500	13.0	36,200
2.6	1,205	4.4	5,160	6.5	11,000	14.0	41,200
2.8	1,535	4.6	5,560	7.0	12,500	15.0	46,200

Estimated monthly discharge of Greenbrier River at Alderson, W. Va.

[Drainage area, 1,344 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	12,350	465	2,585	1.92	2.21
February	28,850	590	4,324	3.22	3.35
March	29,950	1,622	7,339	5.46	6.29
April	7,870	740	3,175	2.36	2.63
May	3,000	387	821	.61	.70
June	4,080	315	677	.50	.56
July	920	170	412	.31	.36
August	280	60	138	.10	.12
September	315	60	96	.07	.08
October	590	170	356	.26	.30
November	3,240	120	565	.92	.47
December	7,090	795	2,865	2.13	2.46
The year	29,950	60	1,946	1.45	19.53

NEW RIVER AT RADFORD, VA.

This river rises in Watauga, Ashe, and Alleghany counties, N. C., and flows in a northwesterly direction into West Virginia, where, after meeting the Gauley, near Kanawha Falls, it is known as the Kanawha. The station at Radford is located at the highway bridge close to the Norfolk and Western Railway station. It was established by D. C. Humphreys August 1, 1898. The gage used was erected by the United States Weather Bureau. It consists of a vertical board graduated to feet and tenths, and is attached to the iron framework connecting the pair of iron concrete cylinders which form the first pier from the right bank. The bench mark is the bottom of the lowest horizontal brace connecting the two cylinders, the elevation being 3.88 feet above the zero of the gage. The discharge measurements are made from the upstream side of the bridge. The initial point for soundings is on the right bank of the river 50 feet from the first pier. The bottom is of solid rock and gravel and is smooth and regular. On the left bank there is a steep, rocky bluff. The right bank is low and subject to overflow for about 100 yards, but all the water must pass under the bridge, which is about 85 feet above low water. On account of the inaccessibility of the Weather Bureau gage, a wire gage was put in

February 23, 1900, the zero being on the same level as that of the old gage. The observer is T. M. Brady, saddler and harness dealer.

The following discharge measurements were made during 1902 by D. C. Humphreys:

July 12: Gage height, —0.40 feet; discharge, 2,820 second-feet.
August 22: Gage height, —0.68 feet; discharge, 2,233 second-feet.

Daily gage height, in feet, of New River at Radford, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.00	3.20	12.00	1.80	0.70	0.20	1.50	0.40	—1.00	—0.80	—0.20	0.70
2	3.00	3.30	6.00	1.60	.70	.30	1.10	.40	—1.00	— .80	.00	.60
3	2.20	4.00	4.20	1.50	.70	.30	.70	.30	—1.10	— .70	.10	.60
4	2.00	3.80	3.00	1.50	.70	.40	.50	.30	— .80	— .70	.10	.80
5	1.80	2.50	3.00	2.00	.60	.50	.20	.30	— .60	— .70	.20	1.40
6	1.80	1.30	2.50	2.20	.60	.60	.20	.20	— .60	.00	.20	1.20
7	1.60	1.20	2.20	2.00	.60	.60	.20	.30	— .60	— .10	.20	1.00
8	1.50	1.00	1.80	1.90	.60	.60	.10	.30	— .70	— .10	.10	1.00
9	1.50	1.00	1.80	1.90	.50	.50	—.10	.40	— .80	— .30	.10	.90
10	1.60	1.20	1.60	1.80	.50	.50	—.20	.30	— .80	— .30	.10	.70
11	1.20	1.10	1.60	1.80	.40	.50	—.20	.20	— .30	— .40	.20	.60
12	1.20	1.00	1.60	1.60	.40	.40	—.20	.20	— .40	— .40	.20	.50
13	1.10	1.90	1.50	1.60	.30	.40	—.20	.10	— .60	— .40	.20	.30
14	1.10	.90	1.50	1.50	.20	.40	—.10	.10	— .60	— .50	.10	.20
15	1.10	.80	1.50	1.50	.20	.20	—.10	.10	— .70	— .60	.10	.20
16	1.10	.80	1.50	1.40	.20	.50	—.00	.20	— .80	— .70	.20	.30
17	1.00	.90	3.00	1.30	.20	3.40	—.10	.00	— .80	— .80	.20	.40
18	1.00	.90	2.60	1.30	.10	2.50	—.20	—.20	— .90	— .80	.20	.40
19	1.00	1.00	2.40	1.20	.10	1.80	—.40	—.40	—1.00	— .80	.40	1.00
20	.90	1.00	2.00	1.20	.00	1.40	—.30	—.60	—1.00	— .90	.30	.80
21	.90	1.10	1.60	1.20	1.00	.80	—.20	—.70	—1.00	— .90	.30	.80
22	1.00	1.20	1.50	1.00	.80	.60	—.20	—.60	— .90	— .90	.20	.70
23	1.00	2.00	1.40	1.00	.80	.40	.00	—.70	— .90	—1.00	.20	.70
24	1.00	3.00	1.40	1.00	.60	.40	.00	—.80	— .80	—1.00	.20	.60
25	1.00	6.83	1.20	.90	.30	.30	.10	—.80	— .80	—1.00	.20	.60
26	1.10	6.50	1.10	.90	.20	.20	.20	—.80	— .80	— .90	.90	.60
27	1.20	3.20	1.00	.90	.20	.10	.20	—.90	— .80	— .80	1.20	.50
28	1.60	15.06	1.00	.80	.10	3.50	.20	—.90	— .80	— .80	1.00	.50
29	2.00	.....	2.50	.80	.00	2.30	.20	—.90	— .90	— .60	.80	.50
30	3.00	.....	2.50	.80	.10	2.00	.30	—.90	— .90	— .40	.80	.40
31	3.40	.....	2.00	.....	.20	.....	.30	—.90	— .90	— .30	.....	.40

NEW RIVER NEAR OLDTOWN, VA.

This station, like those on the North and South Forks of New River, was established to aid in the hydrographic investigations undertaken by the United States Geological Survey in the Southern Appalachian area. It was established July 31, 1900, and is located about 2 miles west of Oldtown. Oldtown is 30 miles from the railroad at Mount Airy, N. C., and 9 miles from a branch of the Norfolk and Western Railway, and can only be reached by private conveyance.

The gaging station was located at Austin's ferry. The wire gage is fixed in an overhanging tree on the left bank, about 50 yards upstream from the ferry. The scale is so placed that the zero mark is next the bank, the distance from the index on the wire to the end of the weight being 16.1 feet. The initial point for soundings is on the right bank and the measurements of discharge are made from the ferryboat. The channel above and below the station is straight and the current swift. The right bank is high and rocky and is never submerged, but the left bank is lower, and at times floods cover it for a considerable distance.

Since the gage rod at this station is so placed that the zero mark is next to the bank the gage readings were reversed, a rise in the water surface being indicated by a decrease in the gage reading, and vice versa. This is true of all figures for gage heights for this station published in Water Supply Papers Nos. 48 and 65. As this arrangement is apt to be misleading and inconvenient, these figures for gage height are reprinted here and are rectified so that an increase in gage height means an increase in volume of flow.

This rectification was made by subtracting all observed gage heights from 7.3 feet, this being the length of the gage, and also the gage height which corresponded to the lowest stage of the stream. Gage heights, as printed herewith, above 7.3 feet are estimated by the observer. The only exception to this rule is the height of the flood of May 22, 1901, which was determined directly by leveling. This was the greatest flood since 1878, when the river rose some 4 or 5 feet higher. Owing to the inaccessibility of this station, no measurements of the flow were made during 1902, though daily records of the stage of the surface have been maintained. This station will shortly be made more accessible by a railroad now nearly completed, when discharge measurements will be begun.

The following discharge measurements were made during 1900, 1901, and 1903:

List of discharge measurements of New River near Oldtown, Va.

Date.	Hydrographer	Gage height.	Discharge.
1900.		*Feet*	*Second-feet.*
July 31	N. C. Curtis	0.70	1,541
Oct. 26	do	1.00	2,293
1901.			
June 29	N. C. Curtis	4.45	6,916
1903.			
Feb. 6	E. W. Myers	1.70	3,533

Daily gage height, in feet, of New River near Oldtown, Va.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.						1900.					
1	0.60	0.50	0.40	0.70	1.00	17	0.30	1.50	0.40	0.50	0.80
2	.60	.40	.50	.70	.90	18	.30	.80	.30	.50	.70
3	.50	.30	.60	1.90	.80	19	.20	.50	.30	.50	.70
4	.50	.20	.70	2.20	1.50	20	.40	.40	.30	.50	.60
5	.40	.20	.90	1.70	2.70	21	.40	.50	.30	.50	.60
6	.40	.20	.90	1.30	1.80	22	.80	.50	.30	.60	.80
7	.40	.20	.80	1.00	1.50	23	.70	.50	.30	.60	.80
8	.30	.20	.70	.90	1.40	24	.60	.60	[a] 8.20	.70	.80
9	.30	.10	.60	.80	1.40	25	.60	.50	3.00	.70	.50
10	.20	.10	.60	.80	1.20	26	.40	.80	1.90	4.90	.60
11	.20	.10	.50	.80	1.20	27	.30	.50	1.40	2.70	.60
12	.10	.10	.40	.70	1.10	28	.30	.40	1.20	1.50	.60
13	.00	.10	.40	.60	1.00	29	.30	.40	1.00	1.30	.60
14	.10	.50	.50	.70	1.00	30	1.00	.50	1.00	1.10	1.00
15	.60	1.60	.40	.70	.80	31	.70	.....	.80	.....	.90
16	.50	3.40	.40	.60	.80						

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	0.90	0.80	0.90	1.60	1.60	2.20	3.20	1.20	4.10	2.10	0.80	0.80
2	.80	.70	.80	2.50	1.40	2.00	2.20	1.10	3.10	3.10	.80	.80
3	.70	.60	.70	6.10	1.40	1.90	1.90	.90	2.60	2.30	.80	1.10
4	.70	1.00	.80	3.80	1.30	1.80	1.90	.90	2.40	1.90	.90	1.50
5	.60	.80	.70	2.60	1.20	1.70	1.90	.90	2.20	1.70	.90	1.50
6	.60	.80	.70	2.10	1.20	1.60	1.80	[a] 13.00	2.10	1.50	.90	1.00
7	.70	.80	.60	2.00	1.30	2.50	2.00	4.90	2.00	1.50	.80	.90
8	.70	.90	.60	1.70	1.40	2.20	1.90	2.90	1.90	1.50	.80	.80
9	.80	1.00	.50	1.60	1.50	1.70	1.60	2.00	1.90	1.40	.80	.80
10	.80	1.00	.90	1.40	1.60	1.60	1.50	1.70	1.70	1.30	.70	1.50
11	1.00	.90	1.40	1.30	1.60	1.60	1.50	1.80	1.70	1.30	.70	1.30
12	3.00	1.00	1.30	1.20	1.50	1.50	1.40	1.90	1.60	1.20	.70	1.10
13	2.40	.90	1.00	1.10	1.20	1.40	1.30	4.30	1.60	2.40	.70	1.00
14	1.80	.70	.90	1.90	1.10	2.40	2.60	6.10	1.50	3.30	.60	2.00
15	1.40	.80	.80	1.80	1.10	4.60	1.40	4.20	1.50	1.90	.60	[a] 10.00
16	1.10	.80	.80	1.50	1.00	3.80	1.60	5.20	1.60	1.60	.60	4.10
17	1.10	.80	.70	1.40	1.50	4.60	1.60	6.20	1.90	1.40	.60	3.00
18	.90	.80	.70	1.20	1.30	3.50	2.40	5.20	2.00	1.20	.50	1.90
19	.80	.70	.60	1.20	1.60	2.90	2.30	4.10	1.90	1.10	.50	1.70
20	.70	.70	.70	.....	1.40	2.40	2.40	3.60	1.70	1.20	.50	1.50
21	1.00	.60	1.10	6.10	1.30	3.00	1.40	3.90	1.50	1.10	.40	1.60
22	1.00	.60	1.00	3.70	16.70	3.80	1.30	3.10	1.40	1.00	.40	1.50
23	.90	[b] .70	.80	2.80	6.10	6.10	1.20	6.10	1.40	1.00	1.40	1.40
24	.90	.....	.70	2.60	3.90	4.60	1.10	3.80	1.20	1.00	1.40	2.50
25	.80	.....	1.00	2.40	3.10	3.00	1.00	3.00	1.10	1.00	1.20	2.30
26	.80	.....	4.00	2.30	2.70	2.80	1.00	2.80	1.10	.90	1.10	2.00
27	.70	.....	3.00	2.20	4.40	2.60	1.10	3.10	2.20	.90	1.00	1.70
28	.70	1.10	1.90	2.10	3.60	2.30	1.20	5.90	2.00	.90	1.00	1.90
29	.60	.....	1.50	2.00	3.30	2.50	1.00	3.70	5.10	.90	.90	[a] 10.00
30	.70	.....	2.00	1.80	2.70	2.10	1.00	3.00	2.80	.80	.70	6.00
31	.80	.....	2.00	.....	2.40	.....	.90	3.10	.....	.80	.....	3.80

[a] Estimated.

[b] Frozen February 24 to 27.

Daily gage height, in feet, of New River near Oldtown, Va.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.00	2.20	6.20	2.10	1.00	0.60	1.90	0.50	0.30	0.40	0.40	1.00
2	2.70	2.50	3.70	1.80	1.00	.70	1.60	.70	.30	.40	.40	1.10
3	2.00	2.30	2.80	1.70	1.00	.70	1.40	.70	.50	.60	.40	1.40
4	2.00	1.90	2.40	1.60	.90	.70	1.10	.70	1.00	.50	.40	1.50
5	1.70	1.90	2.00	1.90	.90	.60	1.00	.60	.80	.80	.40	1.50
6	1.90	1.70	1.90	1.70	1.00	.60	.80	.60	.80	1.00	.50	1.40
7	1.80	1.50	1.90	1.60	1.00	.60	.90	1.40	.40	.70	.60	1.20
8	1.70	1.40	1.80	1.90	1.10	.90	1.10	.80	.40	.60	.70	1.10
9	1.50	1.10	1.80	1.70	1.00	1.00	1.20	.70	1.00	.40	.60	.90
10	1.50	.90	2.00	1.60	.90	1.00	.80	.50	2.00	.40	.50	.90
11	1.40	1.00	1.90	1.50	.80	.90	.80	.50	.90	.60	.50	.90
12	1.30	1.20	1.70	1.50	.90	.90	.70	.40	.60	.90	.40	.80
13	1.10	1.20	1.90	1.40	.80	.60	.70	2.00	.50	1.00	.40	.80
14	1.10	1.10	1.60	1.40	.80	2.10	.80	1.10	.40	.90	.30	.90
15	1.00	1.00	1.50	1.50	1.00	1.90	1.00	.50	.40	.70	.30	.80
16	.40	1.10	1.90	1.50	1.10	3.10	.80	.70	.40	.50	.30	1.00
17	1.30	1.10	2.40	1.40	1.00	2.80	.80	.90	.40	.50	.30	1.60
18	1.20	1.20	2.10	1.30	1.00	1.70	.60	.80	.40	.40	.80	1.30
19	1.20	2.00	1.90	1.20	1.50	1.40	.60	.60	.40	.40	1.10	1.20
20	1.10	1.90	1.70	1.50	1.00	1.20	.60	.50	.40	.40	.70	1.00
21	1.00	2.20	1.60	1.50	1.10	1.10	.50	.50	.50	.40	.60	1.00
22	1.20	1.90	1.50	1.40	.90	1.00	.50	.60	.50	.20	.50	1.20
23	1.10	1.50	1.40	1.30	.90	.90	.60	.60	.40	.20	.50	1.10
24	1.10	1.40	1.40	1.20	1.00	.80	.50	.40	.40	.20	.50	1.00
25	1.20	3.60	1.30	1.20	1.00	.80	.50	.40	.50	.20	.60	.80
26	1.20	3.90	1.20	1.10	1.20	.90	.40	.40	.80	.20	1.00	.60
27	1.00	2.60	1.20	1.00	1.00	2.60	.40	.40	.60	.40	1.20	[b] 1.00
28	2.00	[a] 11.00	1.40	1.00	.90	3.90	.40	.40	.50	.90	1.00	.....
29	1.70	.....	1.90	1.00	.90	4.10	.50	.40	.50	1.10	.80	.....
30	1.90	.....	3.90	1.00	.70	2.20	.70	.30	.40	.70	.70	.....
31	3.00	.....	2.50	.....	.70	.....	.60	.30	.....	.50	.....	.....

[a] Estimated. [b] Frozen December 28 to 31.

NEW RIVER (NORTH FORK) AT WEAVERSFORD, N. C.

During the summer and autumn of 1900, and during a part of the same period in 1901, a special investigation of the hydrographic conditions of the Southern Appalachian region was made by the United States Geological Survey, and as an aid in this work temporary stations were established on a number of the larger streams. Among these were the North and South Forks of New River, while another station was also established below the confluence of these streams, near Oldtown, Va.

The station at Weaversford was established July 27, 1900, by Cleveland Abbe, jr., and N. C. Curtis, and was located about one-fourth of a mile distant from Weaversford post-office and near Dixon's mill. The gage rod is 12.6 feet long and is nailed to the downstream vertical

timber of the forebay of Dixon's mill. The discharge measurements are made by wading at a comparatively shallow ford not on a public road, about 400 yards below the house of Mr. Dixon. The initial point for soundings was on the right bank, and the bed of the stream is rocky and gravelly and constant in form. The banks of the river are high, and previous to the establishment of the station had been overflowed only once, in 1878.

This station was abandoned December 31, 1901.

The following discharge measurements were made in 1900 and 1901:

List of discharge measurements of New River (North Fork) at Weaversford, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 28	N. C. Curtis	0.60	536
Oct. 27	do	.90	708
1901.			
June 27	N. C. Curtis	1.40	1,377

Daily gage height, in feet, of New River (North Fork) at Weaversford, N. C.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.							
1			0.10	0.10	0.70	0.70	0.80
2			.10	.90	.80	.60	.90
3			.10	.90	.75	2.10	.90
4			.10	.90	.45	1.00	1.80
5				.90	.30	.85	1.20
6				.90	.70	.80	.50
7				.90		.70	.50
8				.90		.70	.70
9				1.00		.60	.70
10				1.00		.60	.70
11				1.00		.60	.70
12			.10	1.00		.60	.80
13			.10	.65		.70	.80
14			.30	.90	.90	.70	.90
15			.20	.75	.90	.80	.90
16			.20	.65	.90	.80	.70
17			.10	.55	.90	.90	.70
18			.10	.65	.90	.90	.70
19			.10	.75	1.00	.90	.70
20			.10	.80	1.00	.90	.80
21			.20	.80	1.00	.90	.80
22			.40	.90	1.10	1.00	.80
23			.60	1.00	7.30	1.00	.90
24			.40	.10	5.50	1.00	.90
25			.10	.30	1.70	1.00	.90
26			.10	.40	1.00	3.00	.90

Daily gage height, in feet, of New River (Novth Fork) at Weaversford, N. C.—Continued.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.							
27	.....	1.00	0.10	0.60	0.90	1.00	1.00
28	.....	.50	.10	.80	1.00	2.00	1.00
29	.....	.30	4.10	.90	.90	.50	1.00
30	.....	.20	.10	.65	.90	.60	.....
31	.....	.20	.10	.....	.80	.....	.....
1901.							
1	.....	1.70	.40	1.80	.60	.20	.20
2	.....	.90	.20	1.70	.50	.20	.20
3	.....	.60	.10	1.30	.40	.20	.60
4	.....	.80	.10	1.00	.40	.20	.40
5	.....	.70	2.35	.80	.60	.20	.30
6	.....	.60	5.75	.70	2.30	.20	.30
7	.....	2.00	2.15	.60	1.00	.20	.30
8	.....	.70	9.00	.50	.80	.20	.20
9	.....	.50	7.00	.50	.60	.20	.30
10	.....	.40	7.50	.70	.40	.20	.70
11	.....	.40	5.90	.70	.40	.20	.40
12	.....	.30	3.75	.60	.40	.20	.30
13	.....	.40	3.00	.60	.50	.30	.30
14	.....	.30	3.70	.60	.40	.30	2.00
15	.....	.30	3.00	.60	.40	.20	7.60
16	.....	.40	3.15	.50	.60	.20	1.50
17	.....	1.20	3.40	.50	1.00	.20	1.00
18	.....	1.50	3.60	.80	.70	.30	.80
19	.....	.70	2.00	.50	.60	.30	.60
20	.....	.60	2.60	.40	.30	.30	.60
21	.....	.30	3.00	.60	.20	.30	.40
22	.....	.20	2.60	.40	.20	.20	.50
23	.....	.20	1.25	.60	.20	.20	.40
24	.....	.20	3.00	.40	.20	.40	.30
25	.....	.20	1.00	.40	.20	.40	.30
26	.....	.70	1.50	.30	.20	.30	.60
27	1.00	.70	1.60	.30	.20	.30	1.50
28	1.00	.10	1.80	.70	.20	.30	1.60
29	.90	.10	1.80	.40	.20	.30	10.50
30	1.00	.10	1.20	1.20	.20	.30	4.40
31	.....	.20	1.90	.....	.20	.....	3.40

Rating table for New River (North Fork) at Weaversford, N. C., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	.....	1.6	1,745	3.2	4,705	4.8	7,665
.1	260	1.7	1,930	3.3	4,890	4.9	7,850
.2	300	1.8	2,115	3.4	5,075	5.0	8,035
.3	350	1.9	2,300	3.5	5,260	5.1	8,220
.4	400	2.0	2,485	3.6	5,445	5.2	8,405
.5	455	2.1	2,670	3.7	5,630	5.3	8,590
.6	515	2.2	2,855	3.8	5,815	5.4	8,775
.7	580	2.3	3,040	3.9	6,000	5.5	8,960
.8	650	2.4	3,225	4.0	6,185	5.6	9,145
.9	720	2.5	3,410	4.1	6,370	5.7	9,330
1.0	810	2.6	3,595	4.2	6,555	5.8	9,515
1.1	920	2.7	3,780	4.3	6,740	5.9	9,700
1.2	1,040	2.8	3,965	4.4	6,925	6.0	9,885
1.3	1,200	2.9	4,150	4.5	7,110		
1.4	1,375	3.0	4,335	4.6	7.295		
1.5	1,560	3.1	4,520	4.7	7.480		

Estimated monthly discharge of New River (North Fork) at Weaversford, N. C.

[Drainage area, 278 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1900.					
July [a]	.....	.....	443	1.59	0.28
August [b]	.....	.....	541	1.95	1.74
September	810	260	626	2.25	2.51
October [b]	.....	.....	1,571	5.65	5.05
November	4,335	455	901	3.24	3.61
December [c]	.....	.....	717	2.58	2.97
1901.					
June [d]	.....	.....	788	2.83	.42
July	2,485	260	596	2.14	2.47
August	15,435	260	4,211	15.15	17.46
September	2,115	350	643	2.31	2.58
October	3,040	300	511	1.84	2.12
November	400	300	325	1.17	1.31
December	18,210	300	1,942	6.98	8.06

[a] 5 days. [b] 24 days. [c] 29 days. [d] June 27-30.

NEW RIVER (SOUTH FORK) AT NEW RIVER, N. C.

This station was established July 28, 1900, by Cleveland Abbe, jr., and N. C. Curtis, and was located near New River post-office and about 75 yards upstream from Warden's store.

The gage is a wire cord running over a bolt driven into a locust tree and the stage of the water surface is referred to a horizontal scale, divided into feet and tenths, by means of a pointer securely fastened to the wire 10.55 feet distant from the end of the double sash weights which are lowered to touch the surface of the water when an observation of its height is to be made. The stage is then read direct on the gage rod.

The initial point for soundings at this station was marked by a notch cut in a small poplar tree at the point of gaging, which was at a ford about 1 mile downstream from the gage. The measurements of discharge are made by wading.

The channel is straight, the banks seldom overflow, and the bed of the stream rocky and covered with cobbles and bowlders. This station was abandoned December 31, 1901.

The following discharge measurements were made in 1900 and 1901:

List of discharge measurements of New River (South Fork) at New River, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 28	N. C. Curtis	2.70	751
Oct. 28	do	2.60	1,035
1901.			
June 27	N. C. Curtis	3.90	1,976

Daily gage height, in feet, of New River (South Fork) at New River, N. C.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.							1900.						
1	.....	2.45	2.30	2.30	2.60	2.70	17	.....	2.20	2.80	2.25	2.40	2.60
2	.....	2.35	2.25	2.30	2.60	2.70	18	.....	2.20	2.40	2.20	2.40	2.60
3	.....	2.30	2.20	2.45	3.50	2.70	19	.....	2.20	2.40	2.20	2.40	2.60
4	.....	2.30	2.20	2.80	3.80	3.95	20	.....	2.20	2.30	2.20	2.40	2.60
5	.....	2.30	2.20	2.75	3.30	3.70	21	.....	2.20	2.30	2.20	2.35	2.60
6	.....	2.30	2.20	2.70	2.80	3.20	22	.....	2.30	2.30	2.20	2.30	2.60
7	.....	2.30	2.20	2.55	2.65	2.85	23	.....	2.30	2.30	7.90	2.30	2.70
8	.....	2.30	2.20	2.50	2.60	2.80	24	.....	2.30	2.30	6.70	2.30	2.60
9	.....	2.30	2.20	2.45	2.60	2.80	25	.....	2.30	2.30	3.75	2.70	2.60
10	.....	2.30	2.20	2.40	2.60	2.75	26	.....	2.25	2.30	3.05	5.20	2.60
11	.....	2.30	2.20	2.40	2.60	2.70	27	.....	2.20	2.30	2.90	3.60	2.60
12	.....	2.30	2.15	2.35	2.55	2.70	28	.....	2.20	2.30	2.70	3.05	2.60
13	.....	2.35	2.10	2.30	2.50	2.60	29	2.65	2.50	2.30	2.60	2.95	2.60
14	.....	2.40	2.55	2.30	2.50	2.60	30	2.50	2.45	2.30	2.60	2.80	2.60
15	.....	2.35	2.60	2.30	2.45	2.60	31	2.50	2.35	.....	2.60	.....	2.50
16	.....	2.30	3.70	2.30	2.40	2.60							

Daily gage height, in feet, of New River (South Fork) at New River, N. C.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	2.75	2.55	2.60	3.05	3.40	.....	3.95	2.85	4.80	3.80	2.95	2.70
2	2.70	2.50	2.60	4.45	3.30	.....	3.70	2.80	4.30	3.70	2.90	2.70
3	2.70	2.55	2.55	5.65	3.30	.....	3.60	2.75	4.10	3.70	2.90	3.15
4	2.65	2.80	2.50	4.25	3.25	.....	3.70	2.70	4.05	3.50	2.90	3.15
5	2.60	2.70	2.50	3.70	3.30	.....	3.65	3.95	3.85	3.40	3.00	2.95
6	2.55	2.50	2.50	3.60	3.30	.....	4.05	9.47	3.70	3.30	2.95	2.85
7	2.50	2.55	2.50	3.55	3.20	.....	3.65	5.30	3.65	3.25	2.90	2.75
8	2.50	2.70	2.50	3.40	3.20	.....	3.55	4.00	3.60	3.20	2.90	2.70
9	2.50	3.05	2.50	3.10	3.55	.....	3.45	3.55	3.60	3.15	2.90	2.80
10	2.55	2.95	2.60	3.05	3.45	.....	3.30	3.35	3.60	3.10	2.90	3.80
11	3.20	2.80	3.15	3.00	3.65	.....	3.20	3.35	3.55	3.10	2.90	3.40
12	3.55	2.65	2.95	2.95	3.45	.....	3.20	4.65	3.55	3.10	2.90	3.00
13	3.50	2.60	2.70	3.05	3.20	.....	3.15	6.25	3.60	4.90	2.90	2.90
14	2.95	2.60	2.65	3.80	3.00	.....	3.20	5.60	3.60	4.20	2.85	5.90
15	2.90	2.60	2.60	3.40	3.00	.....	3.25	5.60	3.60	3.25	2.80	13.00
16	2.80	2.60	2.60	3.10	3.00	.....	3.40	5.35	3.60	3.10	2.80	5.40
17	2.80	2.60	2.60	3.05	3.00	.....	3.50	7.20	3.60	3.10	2.80	4.30
18	2.70	2.60	2.50	3.00	3.10	.....	3.50	6.15	3.75	3.10	2.80	3.95
19	2.70	2.60	2.50	4.70	3.25	.....	3.45	5.75	3.60	3.00	2.80	3.85
20	2.70	2.60	2.55	13.30	3.30	.....	2.95	4.70	3.55	3.00	2.80	3.55
21	2.70	2.55	3.00	6.65	8.00	.....	3.00	5.05	3.45	3.00	2.80	3.45
22	2.70	2.55	2.90	4.95	15.00	.....	2.90	4.85	3.40	3.00	2.80	3.35
23	2.70	2.50	2.65	4.55	.....	.....	2.90	5.00	3.40	3.00	3.50	3.25
24	2.70	2.55	2.60	4.45	.....	.....	2.85	5.25	3.30	3.00	3.20	3.25
25	2.65	2.75	2.85	4.25	.....	.....	2.80	4.45	3.30	3.00	2.95	3.45
26	2.55	2.70	5.20	4.05	.....	.....	2.80	5.05	3.25	3.00	2.80	3.55
27	2.65	2.60	5.00	3.75	.....	.....	2.80	4.60	3.15	3.00	2.80	3.60
28	2.60	2.55	3.70	3.70	.....	.....	2.80	5.00	3.40	3.00	2.80	3.70
29	2.65	.....	3.20	3.60	.....	.....	2.90	4.80	5.50	3.00	2.80	6.70
30	2.60	.....	3.40	3.55	.....	.....	2.90	4.55	4.20	3.00	2.75	6.20
31	2.60	.....	3.45	.....	.....	.....	2.90	5.00	.....	3.00	.....	4.80

Rating table for New River (South Fork) at New River, N. C., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	240	4.0	2,090	5.8	4,070	10.0	8,690
2.4	440	4.2	2,310	6.0	4,290	11.0	9,790
2.6	640	4.4	2,530	6.2	4,510	12.0	10,890
2.8	840	4.6	2,750	6.4	4,730	13.0	11,990
3.0	1,040	4.8	2,970	6.6	4,950	14.0	13,090
3.2	1,240	5.0	3,190	6.8	5,170	15.0	14,190
3.4	1,440	5.2	3,410	7.0	5,390		
3.6	1,650	5.4	3,630	8.0	6,490		
3.8	1,870	5.6	3,850	9.0	7,590		

Estimated monthly discharge of New River (South Fork) at New River, N. C.

[Drainage area, 327 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1900.					
July[a]			590	1.80	0.20
August	540	240	342	1.05	1.21
September	1,760	200	389	1.19	1.33
October	6,380	240	878	2.68	3.09
November	3,410	340	820	2.51	2.80
December	2,035	640	789	2.41	2.78
1901.					
January	1,595	540	779	2.38	2.75
February	1,090	540	677	2.07	2.16
March	3,410	540	957	2.93	3.37
April	12,320	990	2,275	6.96	8.88
May[b]			2,123	6.49	5.31
June					
July	2,145	840	1,302	3.99	5.75
August	8,000	740	2,659	8.13	9.37
September	3,740	1,190	1,489	4.55	5.07
October	3,080	1,040	1,305	3.99	4.60
November	1,540	790	932	2.85	3.17
December	11,990	740	2,187	6.69	7.71

[a] Three days. [b] May (1-22).

CUMBERLAND DRAINAGE BASIN.

Cumberland River rises in the eastern part of Kentucky and flows west till it meets the South Fork, which rises in northern Tennessee and flows northward. After this junction the Cumberland turns toward the southwest into Tennessee, and, after flowing through the north-central part, again enters Kentucky in Trigg County, flows across the State, and enters the Ohio River at Smithland, about 15 miles above the mouth of Tennessee River. The gaging station on this river is located at Nashville, Tenn., and is under the care of B. M. Hall.

CUMBERLAND RIVER AT NASHVILLE, TENN.

The gage, which belongs to the United States Engineer Corps, is at the foot of Broad street. It is in three sections, two of which are upright and one inclined. The lowest section, extending from −0.2 foot to +46 feet, is on the slope of the bank and consists of timbers

embedded in the ground, bearing an iron strap, into which the markings are cut. The section extending from gage height 46 to 53 feet is fastened to a small building at the top of the bank, and consists of a timber painted white with black markings. The top section of the gage, extending from 52 feet to 55.3 feet, is on the corner of Temperance Hall, painted on the stones in white with black markings. In addition there is a vertical section reading from −1.2 feet to +2 feet. The datum of the gage corresponds to elevation 110.3 feet of the city levels. A cross, cut on the upper face of the corner stone in the southeast corner of Temperance Hall, on Broad street, near Front street, is 52 feet above the zero of the gage, and 366.6 feet above mean sea level. The highest observed water was 55.3 feet on January 22, 1882. The lowest occurred on October 15 and 16, 1878, at a gage height of −0.4 foot. The danger line is at 40 feet.

Records have been kept for a number of years by the United States Weather Bureau, from which readings previous to those here published may be obtained.

Daily gage height, in feet, of Cumberland River at Nashville, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	27.40	39.00	16.80	44.00	15.40	3.60	7.60	1.70	1.60	5.50	1.60	19.40
2	29.10	40.30	16.90	45.40	24.00	3.50	7.20	2.80	2.50	5.40	1.60	18.00
3	29.40	40.30	20.70	46.00	22.20	3.30	7.70	2.60	2.10	4.60	1.50	17.20
4	27.90	40.80	21.70	46.00	21.90	3.20	8.40	2.20	2.50	4.30	1.40	18.60
5	24.30	40.10	22.50	46.10	21.60	3.00	9.00	2.10	2.30	3.30	1.50	19.20
6	19.10	38.20	26.00	45.20	17.00	3.00	8.80	2.00	2.10	3.00	1.50	21.50
7	14.90	30.80	27.80	39.70	13.50	2.80	7.80	2.00	1.90	2.50	1.50	20.50
8	12.10	22.60	30.10	30.20	13.80	2.80	7.30	1.80	1.80	2.20	1.40	19.60
9	10.60	16.00	32.10	21.40	10.40	2.60	6.40	4.20	1.90	2.10	1.40	18.70
10	9.60	12.70	32.30	16.60	8.80	2.50	4.40	4.10	1.70	1.90	1.40	17.40
11	8.70	11.10	31.60	14.50	7.90	2.50	3.50	3.70	1.50	2.00	1.50	15.80
12	7.90	9.80	29.60	13.20	7.80	2.90	3.30	2.20	1.40	2.60	1.40	13.70
13	7.30	8.80	28.20	11.80	7.20	2.40	3.10	2.00	1.30	3.20	1.40	11.40
14	6.90	7.60	25.20	10.70	6.90	2.30	3.10	2.20	1.20	5.10	1.30	9.40
15	6.30	7.10	21.50	9.80	6.70	2.30	3.00	2.10	1.10	6.80	1.30	12.80
16	6.00	6.90	19.00	9.10	6.60	2.20	2.70	2.10	1.10	6.40	1.30	26.50
17	5.70	6.60	19.60	8.50	6.60	2.10	2.30	2.20	1.00	5.80	1.30	30.30
18	5.30	6.20	20.60	8.10	6.40	2.10	2.20	2.10	1.00	5.20	1.40	31.20
19	5.30	6.00	21.30	7.70	5.60	2.00	2.00	2.10	1.20	5.10	1.40	31.30
20	5.40	5.90	21.60	7.40	5.10	2.00	2.10	2.10	1.20	4.40	1.50	32.80
21	6.00	5.80	21.20	6.90	5.20	2.10	2.50	2.00	1.10	4.10	1.80	33.30
22	9.90	5.90	20.50	5.80	4.80	2.20	1.90	2.00	1.00	3.60	1.90	32.40
23	10.70	6.00	19.20	5.70	4.70	2.20	2.20	1.90	1.00	3.40	2.10	31.20
24	11.70	8.80	14.30	5.60	4.60	2.20	1.90	1.80	1.10	3.10	2.10	23.20
25	11.90	10.50	12.30	5.60	4.40	2.00	1.80	1.90	1.50	2.80	3.60	21.00
26	12.40	13.10	10.90	5.90	4.20	2.10	1.70	1.90	2.60	2.40	11.80	18.40
27	17.50	13.00	9.90	6.00	3.90	2.40	1.60	1.80	3.20	2.10	15.20	16.20
28	22.70	15.00	10.10	6.20	3.60	2.50	1.60	1.90	3.10	2.00	17.50	13.80
29	24.80	.....	32.70	7.00	3.50	2.90	1.90	1.80	2.80	2.00	18.80	12.30
30	31.20	.....	43.40	9.10	3.40	6.70	2.20	1.70	2.90	1.80	19.60	13.40
31	35.20	.....	44,70	.....	3.30	.....	1.80	1.60	.....	1.70	.....	12.90

MISCELLANEOUS MEASUREMENTS IN CUMBERLAND DRAINAGE BASIN.

The following miscellaneous discharge measurements were made in the Cumberland drainage basin in 1902 by B. M. Hall and his assistants:

Date.	Stream.	Locality.	Discharge.
May 19..	Clear Fork of Cumberland River.	One-half mile from Clearfield, Tenn.	12
Dec. 11..	Cumberland River	Burnside, Ky	3,295

TENNESSEE RIVER DRAINAGE BASIN.

Tennessee River is formed by the junction of the French Broad and the Holston about 4 miles above Knoxville, Tenn. It flows southwest, crossing into Alabama about 40 miles below Chattanooga, Tenn., and, after crossing the northern part of Alabama, again enters Tennessee in Harding County. It then flows north, crossing Tennessee and Kentucky, and enters the Ohio River at Paducah, about 40 miles above Cairo. Its principal tributary on the north is Clinch River, which enters it near Kingston, Roan County, Tenn. The principal tributaries on the south are Hiwassee and Little Tennessee rivers. The Hiwassee rises in the northern part of Georgia and flows into the Tennessee about 30 miles above Chattanooga. Its principal tributaries are the Ocoee and the Nottely. Little Tennessee River rises in the northern part of Georgia, flows across the southwestern part of North Carolina, and enters the Tennessee near Loudon, Tenn. Its principal tributary is the Tuckasegee. French Broad River rises in the western part of North Carolina. Its principal tributaries are the Pigeon and the Nolichucky. Holston River rises in the western part of Virginia. Its principal tributary is Watauga River, into which stream Roan Creek enters. During 1902 the United States Geological Survey maintained the following stations in this basin under the supervision of B. M. Hall and E. W. Myers, resident hydrographers for this section: On the Tennessee at Chattanooga, Tenn.; on the Hiwassee at Charleston, Tenn.; on the Toccoa (Okoee), near Blueridge, Ga.; on the Hiwassee at Reliance, Tenn.; on the Nottely at Ranger, N. C.; on the Hiwassee at Murphy, N. C.; on the Little Tennessee at Judson, N. C.; on the Tuckasegee at Bryson, N. C.; on the Tennessee at Knoxville, Tenn.; on the French Broad at Oldtown, near Newport, Tenn.; on the Pigeon at Newport, Tenn.; on the Nolichucky River, near Chucky Valley, Tenn.; on the Holston (S. F.) at Bluff City, Tenn.; on the Watauga at Butler, Tenn.; on Roan Creek at Butler, Tenn.

TENNESSEE RIVER AT CHATTANOOGA, TENN.

This station was established in 1879, at the foot of Lookout street, just below Chattanooga Island, by the Signal Corps of the United States Army; but since July 1, 1891, it has been in charge of the Weather Bureau. During the year 1900 a new gage was established. It is a vertical rod bolted to the south side of the third stone pier from the south end of the Hamilton County highway bridge. During the present year the self-registering gage invented by Professor Fulton, of Tennessee University, has been in use at this station. The gage is connected by wire with the Weather Bureau office, and a continuous electrical record of river height is made in the same manner as the record of wind, sunshine, etc. Gage heights are furnished to the Geological Survey through L. M. Pindell.

The following discharge measurements were made during 1902:

June 25: Gage height, 3.80 feet; discharge, 17,773 second-feet.
October 9: Gage height, 2.00 feet; discharge, 10,678 second-feet.
November 14: Gage height, 1.55 feet; discharge, 9,282 second-feet.

Daily gage height, in feet, of Tennessee River at Chattanooga, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	40.10	20.10	24.00	30.90	5.60	4.00	9.80	2.20	1.40	3.90	1.30	5.20
2	40.80	21.80	31.90	27.00	8.50	3.80	10.20	2.00	1.20	3.70	1.30	5.10
3	37.60	23.20	35.80	18.00	9.30	3.60	8.80	2.10	1.20	3.90	1.40	6.70
4	26.80	21.70	38.00	12.30	8.00	3.50	7.50	2.40	1.50	3.30	1.50	7.40
5	15.00	18.00	35.90	10.70	6.80	3.40	6.50	2.40	1.30	3.00	1.50	7.80
6	10.90	14.50	30.30	10.00	6.00	3.40	5.50	2.80	1.40	2.80	1.50	7.50
7	9.70	11.70	25.50	9.50	5.60	3.20	4.50	2.50	1.50	2.40	1.40	7.50
8	8.90	10.00	20.70	9.80	5.60	3.20	4.00	2.10	1.50	2.10	1.80	6.60
9	8.00	8.80	17.90	9.90	5.50	3.30	3.70	1.90	1.50	2.00	2.20	6.00
10	7.70	8.10	15.60	9.50	5.20	3.40	3.50	2.20	1.50	1.90	2.10	5.30
11	7.30	7.50	14.20	8.90	5.00	3.20	3.40	2.80	1.40	2.20	1.90	4.70
12	6.90	6.90	12.90	8.40	4.80	3.40	3.40	2.70	1.50	2.90	1.80	4.20
13	6.50	6.40	12.10	8.00	4.60	3.50	3.60	2.40	1.90	2.70	1.80	3.90
14	6.20	6.00	11.20	7.50	4.50	3.30	4.80	2.00	2.10	2.70	1.60	3.60
15	5.80	6.00	10.50	7.30	4.50	3.10	5.00	1.70	2.00	3.30	1.50	3.40
16	5.50	6.10	10.00	7.10	4.60	3.00	4.20	1.60	1.90	3.40	1.40	3.50
17	5.30	6.00	12.20	6.90	4.70	3.00	3.80	1.50	1.80	3.50	1.40	4.80
18	5.10	5.80	14.50	6.80	4.50	3.00	3.30	1.50	1.50	3.00	1.40	7.40
19	5.10	5.60	14.90	6.70	4.50	4.00	3.10	1.50	1.40	2.80	1.70	7.80
20	5.20	5.50	14.10	6.60	4.40	4.50	2.90	1.40	1.40	2.60	1.90	7.20
21	5.40	5.20	12.30	6.50	4.40	4.60	2.60	1.50	1.40	2.20	2.10	7.00
22	6.20	5.70	10.60	6.30	4.50	4.40	2.70	1.60	2.00	2.00	1.90	8.70
23	6.50	6.80	9.50	6.10	4.80	4.00	2.90	1.60	2.60	1.80	1.90	9.60
24	6.70	7.90	8.90	6.00	4.60	3.90	2.60	1.50	2.60	1.80	2.00	8.70
25	6.60	8.10	8.30	5.90	4.60	3.70	2.30	1.40	2.80	1.60	2.10	7.20
26	6.10	8.50	7.80	5.70	4.50	3.50	2.00	1.40	3.30	1.50	3.50	6.50
27	6.30	8.60	7.50	5.50	4.20	4.00	2.00	1.50	3.60	1.40	6.10	5.70
28	8.50	13.30	7.20	5.40	4.00	3.90	1.90	1.50	3.60	1.40	6.30	5.10
29	12.60	.....	12.90	5.20	4.40	4.00	1.90	1.60	3.60	1.30	5.80	4.50
30	15.80	.....	26.50	5.20	4.50	5.00	2.00	1.90	3.50	1.20	5.40	4.30
31	18.90	.....	31.00	.....	4.30	.....	2.30	1.70	.....	1.20	.....	4.60

Rating table for Tennessee River at Chattanooga, Tenn., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	8,040	5.2	28,240	14.0	85,200	24.0	150,200
1.4	8,820	5.4	29,480	14.5	88,450	24.5	153,450
1.6	9,620	5.6	30,720	15.0	91,700	25.0	156,700
1.8	10,430	5.8	31,960	15.5	94,950	25.5	159,950
2.0	11,250	6.0	33,200	16.0	98,200	26.0	163,200
2.2	12,080	6.5	36,450	16.5	101,450	27.0	169,700
2.4	12,930	7.0	39,700	17.0	104,700	28.0	176,200
2.6	13,800	7.5	42,950	17.5	107,950	29.0	182,700
2.8	14,680	8.0	46,200	18.0	111,200	30.0	189,200
3.0	15,600	8.5	49,450	18.5	114,450	31.0	195,700
3.2	16,550	9.0	52,700	19.0	117,700	32.0	202,200
3.4	17,550	9.5	55,950	19.5	120,950	33.0	208,700
3.6	18,550	10.0	59,200	20.0	124,200	34.0	215,200
3.8	19,600	10.5	62,450	20.5	127,450	35.0	221,700
4.0	20,800	11.0	65,700	21.0	130,700	36.0	228,200
4.2	22,040	11.5	68,950	21.5	133,950	37.0	234,700
4.4	23,280	12.0	72,200	22.0	137,200	38.0	241,200
4.6	24,520	12.5	75,450	22.5	140,450	39.0	247,700
4.8	25,760	13.0	78,700	23.0	143,700	40.0	254,200
5.0	27,000	13.5	81,950	23.5	146,950		

Estimated monthly discharge of Tennessee River at Chattanooga, Tenn.

[Drainage area, 21,418 miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	259,400	27,620	70,567	3.29	3.79
February	145,000	28,240	60,106	2.81	2.93
March	241,200	41,000	108,411	5.06	5.83
April	195,050	28,240	54,811	2.56	2.86
May	54,650	20,800	28,283	1.32	1.52
June	27,000	15,600	19,043	.89	.99
July	60,500	10,840	22,414	1.05	1.21
August	14,680	8,820	10,892	.51	.59
September	18,550	8,040	11,376	.53	.59
October	20,200	8,040	13,260	.62	.71
November	35,150	8,430	13,298	.62	.69
December	56,600	17,550	33,763	1.58	1.82
The year	259,400	8,040	37,185	1.74	23.53

HIWASSEE RIVER AT CHARLESTON, TENN.

The gaging station on this river is located at the bridge of the Southern Railway, 600 feet from the depot, in the town of Charleston, Tenn. It is 17 miles from the mouth of the river and 53 miles above Chattanooga, Tenn. This station was originally established by the United States Engineer Corps, but is now maintained half the year by the United States Weather Bureau and the other half by the United States Geological Survey. The gage rod is fastened to the downstream end of the south pier of the bridge, 125 feet from the shore. It is painted white, and marked in feet and tenths. The bench mark is a cross, cut in the top surface of the upper corner stone of the pier, and is 35 feet above the zero of the gage. The greatest height recorded at this point was on March 31, 1886, when the gage read 32.2 feet. The danger line is placed at 22 feet. The railroad bridge is an iron three-span bridge, with a total length of 390 feet. There are embankments at each end which confine the water, even at the highest stages. The observer is J. C. Bates, Charleston, Tenn.

In 1902 the following discharge measurement was made:

November 15: Gage height, 0.40 foot; discharge, 1,306 second-feet.

Daily gage height, in feet, of Hiwassee River at Charleston, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	17.00	10.20	23.00	9.50	3.20	1.60	1.30	0.80	0.50	1.50	0.30	1.60
2	15.90	12.00	15.10	6.50	5.00	1.60	1.10	.70	.50	1.30	.30	1.90
3	11.30	11.70	14.60	5.00	4.10	1.70	1.10	1.20	1.00	.90	.30	6.00
4	5.50	7.90	14.50	4.70	3.30	1.60	1.00	.90	.60	.70	.30	5.00
5	4.60	6.00	12.70	4.70	2.90	1.50	1.00	1.60	.60	.60	.30	3.70
6	4.20	5.00	11.10	4.20	2.80	1.40	1.10	1.00	.70	.60	.30	3.20
7	3.90	4.50	8.10	4.70	2.70	1.50	1.00	.60	.40	.80	1.60	2.40
8	3.70	4.10	6.50	5.90	3.20	1.60	1.00	.50	.40	.60	1.10	2.00
9	3.50	3.80	7.20	5.40	2.60	2.10	1.00	.40	.30	.50	.80	1.80
10	3.30	3.50	6.60	4.50	2.50	1.70	.90	.40	.30	.40	.60	1.60
11	3.20	3.30	5.80	4.10	2.40	1.50	1.00	.60	.30	.60	.60	1.50
12	3.00	3.10	5.30	3.90	2.30	1.40	1.00	.80	.40	1.60	.50	1.40
13	2.80	3.10	5.00	3.70	2.20	1.30	1.70	.60	.60	1.40	.50	1.30
14	2.70	3.00	5.10	3.60	2.50	1.30	1.90	.40	.90	2.30	.40	1.30
15	2.70	3.10	4.50	3.60	2.50	1.40	2.00	.40	1.00	1.50	.40	1.20
16	2.60	3.10	5.50	3.50	2.30	1.40	2.00	.40	.60	1.20	.40	1.50
17	2.60	3.00	10.00	3.40	2.20	1.30	1.20	.50	.30	.90	.40	3.40
18	2.50	2.90	7.00	3.60	2.30	1.30	1.00	.40	.40	.70	1.10	3.30
19	2.70	2.80	5.60	3.40	2.30	1.30	.80	.30	.40	.60	1.60	2.40
20	3.00	2.80	5.00	3.30	2.30	1.40	1.00	.30	.50	.60	1.00	2.00
21	2.80	3.00	4.60	3.20	2.20	1.30	1.30	.30	1.20	.50	.80	2.10
22	3.80	4.70	4.40	3.00	2.10	2.00	1.30	.30	.40	.50	.60	6.20
23	3.40	4.60	4.20	2.90	1.90	1.50	1.20	.30	.40	.50	.60	4.40
24	2.90	3.90	4.00	2.90	1.90	1.20	.80	.20	.30	.40	.60	3.10
25	2.80	3.90	3.80	2.80	1.90	1.10	.70	.10	2.10	.40	1.00	2.50
26	2.80	4.70	3.70	2.70	1.80	2.00	.70	.60	2.40	.40	6.60	2.30
27	2.90	4.20	3.50	2.70	1.90	2.20	.60	.30	1.70	.40	3.30	2.00
28	5.00	17.60	3.70	2.70	1.80	1.80	.60	.70	1.40	.40	2.20	1.70
29	4.70	.....	11.50	2.60	1.70	1.40	.90	.80	1.30	.40	1.70	1.70
30	4.70	.....	16.30	3.40	1.60	1.40	1.30	1.00	1.30	.30	1.50	2.60
31	6.50	.....	11.60	.....	1.60	.....	.90	.60	.....	.30	.....	2.70

Rating table for Hiwassee River at Charleston, Tenn., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	1,200	3.4	5,580	7.5	11,525	15.5	23,125
.4	1,380	3.6	5,870	8.0	12,250	16.0	23,850
.6	1,580	3.8	6,160	8.5	12,975	16.5	24,575
.8	1,820	4.0	6,450	9.0	13,700	17.0	25,300
1.0	2,100	4.2	6,740	9.5	14,425	17.5	26,025
1.2	2,390	4.4	7,030	10.0	15,150	18.0	26,750
1.4	2,680	4.6	7,320	10.5	15,875	19.0	28,200
1.6	2,970	4.8	7,610	11.0	16,600	20.0	29,650
1.8	3,260	5.0	7,900	11.5	17,325	21.0	31,100
2.0	3,550	5.2	8,190	12.0	18,050	22.0	32,550
2.2	3,840	5.4	8,480	12.5	18,775	23.0	34,000
2.4	4,130	5.6	8,770	13.0	19,500	24.0	35,450
2.6	4,420	5.8	9,060	13.5	20,225	25.0	36,900
2.8	4,710	6.0	9,350	14.0	20,950		
3.0	5,000	6.5	10,075	14.5	21,675		
3.2	5,290	7.0	10,800	15.0	22,400		

Estimated monthly discharge of Hiwassee River at Charleston, Tenn.

[Drainage area, 2,297 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	25,300	4,275	7,339	3.20	3.69
February	26,170	4,710	8,185	3.56	3.71
March	34,000	5,725	12,320	5.36	6.18
April	14,425	4,420	6,455	2.81	3.14
May	7,900	2,970	4,205	1.83	2.11
June	3,840	2,245	2,864	1.25	1.39
July	3,550	1,580	2,265	.99	1.14
August	2,970	1,120	1,598	.70	.81
September	4,130	1,285	1,859	.81	.90
October	3,985	1,285	1,837	.80	.92
November	10,220	1,285	2,260	.98	1.09
December	9,640	2,390	4,383	1.91	2.20
The year	34,000	1,120	4,631	2.02	27.28

TOCCOA (OKOEE) RIVER NEAR BLUERIDGE, GA.

This stream, called Toccoa River in Georgia and Okoee River in Tennessee, has its source on the northern slopes of the Blue Ridge Mountains in Georgia and flows northwest into Hiwassee River. The area is covered with a fine growth of oak, hickory, and other hard woods. The station, established by B. M. Hall on November 25, 1898, is located at the Morganton bridge, about 4 miles east of the town of Blueridge, Ga. The gage is a 14-foot rod, in two 7-foot sections, nailed to a tree on the right bank just below the bridge. It is graduated to feet and tenths and is set to conform to bench marks which were established October 15, 1896, and October 26, 1898. The measurements during 1896 were made at the railroad bridge about 3 miles below, but are referred to the present gage by comparison of the bench marks at the two bridges. The bench mark at Morganton bridge is on the top of the bridge floor, on the downstream side, 50 feet from the initial point, and is 18 feet above the zero of the gage. The bridge was a wooden, queen-post, open bridge, in three spans, with a total length between abutments of 153 feet, but it has been remodeled and changed into a closed bridge, not suitable for use in making discharge measurements at such an irregular section. Measurements are now made at a ferry about 2½ miles below, but the gage at the bridge is still maintained. The observer is W. E. Rogers, a farmer living about a quarter of a mile east of the gage.

The following discharge measurements were made during 1902:

April 25: Gage height, 3.20 feet; discharge, 749 second-feet.
November 21: Gage height, 2.15 feet; discharge, 253 second-feet.

Daily gage height, in feet, of Toccoa River near Blueridge, Ga.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.00	4.00	4.00	4.80	3.50	2.80	2.50	2.60	2.80	2.50	2.40	3.00
2	5.00	4.00	4.00	4.80	3.50	2.80	2.50	2.60	3.00	2.50	2.40	4.00
3	5.00	4.00	4.00	4.60	3.40	2.80	2.50	2.40	3.00	2.50	2.40	4.00
4	4.60	4.00	4.00	4.60	3.00	2.80	2.50	2.40	3.00	2.50	2.40	4.00
5	4.50	4.00	3.80	4.50	3.00	2.80	2.50	2.40	3.00	2.60	2.40	4.00
6	4.30	4.00	3.80	4.00	3.00	2.80	2.50	2.30	2.80	2.60	2.40	3.50
7	4.00	4.00	3.70	4.00	3.00	2.80	2.50	2.30	2.80	2.60	3.00	3.50
8	4.00	4.00	3.70	4.00	3.00	3.00	2.40	2.30	2.80	2.60	3.00	3.50
9	4.00	4.00	4.00	4.00	3.00	3.00	2.40	2.30	2.60	2.60	3.00	3.00
10	4.00	4.00	6.00	4.80	3.00	3.00	2.40	2.30	2.60	2.60	2.50	3.00
11	4.00	4.00	5.50	4.80	3.00	3.00	2.30	2.30	2.60	2.60	2.50	3.00
12	3.60	4.30	5.50	4.00	3.00	3.00	2.60	2.30	3.00	2.60	2.40	3.00
13	3.60	4.20	5.00	4.00	3.00	3.00	2.40	2.30	3.00	2.60	2.40	3.00
14	3.60	4.00	5.00	3.80	3.00	3.00	2.40	2.30	2.80	2.60	2.40	3.00
15	3.50	4.00	5.00	3.80	3.00	2.80	2.40	2.30	2.80	2.50	2.40	3.00
16	3.50	4.00	5.00	3.80	3.00	2.80	2.40	2.30	2.80	2.50	2.40	3.00
17	3.50	4.00	4.80	3.60	3.00	2.80	2.40	2.20	2.80	2.50	2.40	3.00

Daily gage height, in feet, of Toccoa River near Blueridge, Ga.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
18	3.50	4.00	4.80	3.60	3.00	2.80	2.40	2.20	2.80	2.50	2.40	3.00
19	3.50	6.00	4.60	3.60	3.00	2.70	2.40	2.20	2.80	2.50	2.40	3.00
20	3.50	10.00	4.60	3.40	3.00	2.70	2.40	2.20	2.80	2.50	2.40	3.00
21	3.40	5.00	4.30	3.40	3.00	2.70	2.40	2.20	2.80	2.50	2.30	3.50
22	3.40	5.00	4.00	3.40	3.00	2.60	2.40	2.20	2.70	2.50	2.30	3.50
23	3.40	5.00	4.00	3.40	3.00	2.60	2.40	2.20	2.70	2.50	2.30	3.50
24	3.40	4.00	4.00	3.20	3.00	2.50	2.40	2.20	2.60	2.50	2.30	3.20
25	3.40	4.00	4.00	3.20	3.00	2.50	2.40	2.20	2.60	2.50	4.00	3.00
26	4.00	4.00	4.00	3.20	3.00	2.50	2.40	2.20	2.60	2.40	3.00	3.00
27	4.00	4.00	4.00	3.40	3.00	2.50	2.40	3.00	2.60	2.40	3.00	3.00
28	5.00	4.00	3.80	3.40	3.00	2.50	2.40	3.00	2.50	2.40	3.00	3.00
29	5.00	.....	6.00	3.40	2.80	2.50	2.40	3.00	2.50	2.40	3.00	3.00
30	4.50	.....	5.00	3.50	2.80	2.50	2.40	2.80	2.50	2.40	3.00	3.00
31	4.50	.....	5.00	.....	2.80	.....	2.60	2.80	.....	2.40	.....	3.00

Rating table for Toccoa (Okoee) River near Blueridge, Ga., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	270	3.6	1,162	5.0	2,660	6.8	4,586
2.3	312	3.7	1,269	5.1	2,767	7.0	4,800
2.4	355	3.8	1,376	5.2	2,874	7.2	5,014
2.5	400	3.9	1,483	5.3	2,981	7.4	5,228
2.6	447	4.0	1,590	5.4	3,088	7.6	5,442
2.7	497	4.1	1,697	5.5	3,195	7.8	5,656
2.8	550	4.2	1,804	5.6	3,302	8.0	5,870
2.9	606	4.3	1,911	5.7	3,409	9.0	6,940
3.0	666	4.4	2,018	5.8	3,516	10.0	8,010
3.1	732	4.5	2,125	5.9	3,623	11.0	9,080
3.2	804	4.6	2,232	6.0	3,730	12.0	10,150
3.3	883	4.7	2,339	6.2	3,944	13.0	11,220
3.4	969	4.8	2,446	6.4	4,158	14.0	12,290
3.5	1,062	4.9	2,553	6.6	4,372		

Estimated monthly discharge of Toccoa (Okoee) River near Blueridge, Ga.

[Drainage area, 231 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	2,660	969	1,602	6.94	8.00
February	8,010	1,590	2,029	8.78	9.14
March	3,730	1,269	2,104	9.11	10.50
April	2,446	804	1,459	6.32	7.05
May	1,062	550	690	2.99	3.45
June	666	400	530	2.29	2.55
July	447	312	370	1.60	1.84
August	666	270	361	1.56	1.80
September	666	400	531	2.30	2.57
October	447	355	406	1.76	2.03
November	1,590	312	476	2.06	2.30
December	1,590	666	866	3.75	4.32
The year	8,010	270	952	4.12	55.55

HIWASSEE RIVER AT RELIANCE, TENN.

This station was established by O. P. Hall on August 17, 1900. The gage is a vertical timber, graduated to feet and tenths, spiked to a tree on the right bank of the river about 200 feet above the Atlanta, Knoxville and Northern Railroad bridge, and very near the ferry landing. Measurements are made from the railroad bridge, a new steel structure of three spans of 140 feet each, which has recently been substituted for the old wooden bridge. Bench mark No. 1 is a nail in a notch cut in a hickory tree on the right bank of the river, about 75 feet above the end of the bridge and 5.82 feet above the zero of the gage. Bench mark No. 2 is the top of bridge girder downstream, 40 feet from the right-bank end of the bridge, and is 23.90 feet above the zero of the gage. At ordinary stages the river is about 350 feet wide at this point, and the section is a fairly good one, but at low stages the current becomes sluggish. The observer is C. V. Higdon, a farmer and ferryman, who lives near the gage.

During 1902 the following discharge measurements were made:

April 23: Gage height, 2.05 feet; discharge, 2,972 second-feet.
August 11: Gage height, 0.86 foot; discharge, 832 second-feet.
October 1: Gage height, 1.28 feet; discharge, 1,236 second-feet.
November 19: Gage height, 1.37 feet; discharge, 1,372 second-feet.

Daily gage height, in feet, of Hiwassee River near Reliance, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.40	4.50	6.30	3.00	2.10	1.50	1.30	1.00	0.90	1.20	0.90	1.50
2	3.00	5.70	3.30	2.80	2.40	1.40	1.30	1.10	.80	1.20	.90	1.60
3	2.80	4.30	3.60	2.70	2.10	1.40	1.30	1.00	.80	1.10	.90	3.00
4	2.60	3.30	3.20	2.70	2.00	1.50	1.30	1.20	.90	1.00	.90	2.50
5	2.40	2.90	3.60	2.60	2.00	1.40	1.40	1.00	1.20	1.00	.90	2.20
6	2.40	2.70	3.30	2.50	1.90	1.40	1.30	1.00	1.00	1.00	.90	2.00
7	2.30	2.50	3.00	2.60	1.90	1.40	1.10	1.00	.90	1.10	1.50	1.70
8	2.20	2.40	2.90	3.20	1.90	1.50	1.20	.90	.80	1.00	1.20	1.60
9	2.20	2.30	2.40	2.80	1.90	1.40	1.10	.80	.80	.90	1.00	1.50
10	2.10	2.20	2.10	2.60	1.80	1.60	1.10	.80	.90	.90	1.00	1.40
11	2.00	2.20	2.90	2.50	1.80	1.50	1.20	.80	1.20	1.00	1.00	1.50
12	2.00	2.10	2.80	2.40	1.70	1.40	1.30	.80	1.00	1.20	1.00	1.40
13	1.90	2.10	2.70	2.60	1.80	1.40	1.90	.80	.90	1.50	1.00	1.40
14	1.90	2.00	2.70	2.30	1.90	1.30	1.40	.80	1.20	1.40	1.00	1.40
15	1.90	2.00	2.60	2.40	1.90	1.30	1.90	.80	1.00	1.40	1.00	1.30
16	1.90	2.10	2.90	2.30	1.90	1.40	1.50	.90	.90	1.20	1.00	1.60
17	1.90	2.10	3.80	2.30	1.80	1.30	1.20	.80	.90	1.10	.90	2.60
18	1.80	2.00	3.00	2.30	1.80	1.30	1.10	.80	.80	1.00	1.40	2.10
19	2.00	1.90	2.80	2.20	1.80	1.40	1.10	.80	.80	1.00	1.50	1.80
20	2.10	1.90	2.70	2.20	1.80	1.40	1.10	.80	1.50	1.00	1.20	1.70
21	2.10	2.10	2.60	2.20	1.70	1.30	1.10	.80	1.20	1.00	1.10	1.80
22	2.50	2.70	2.60	2.20	1.70	1.60	1.10	.80	1.10	1.00	1.10	3.10
23	2.10	2.50	2.50	2.10	1.60	1.30	1.00	.80	1.00	.90	1.10	2.30
24	2.00	2.30	2.40	2.10	1.60	1.20	1.00	.70	1.00	.90	1.00	2.00
25	1.90	2.40	2.40	2.00	1.60	1.20	1.00	.70	1.10	.90	1.70	1.90
26	1.90	2.50	2.30	2.00	1.70	1.40	1.00	.70	1.70	.90	3.00	1.70
27	2.00	2.40	2.30	2.00	1.70	1.70	.90	.90	1.50	.90	2.00	1.60
28	2.60	10.00	2.40	1.90	1.60	1.40	.90	1.20	1.30	.90	1.70	1.60
29	2.50	.....	5.50	2.00	1.50	1.40	1.00	1.20	1.30	1.00	1.50	1.60
30	2.50	.....	4.50	2.10	1.50	1.30	1.10	1.10	1.10	.90	1.50	1.90
31	3.10	.....	3.50	.....	1.50	.....	1.10	.90	.....	.90	.....	1.80

Rating table for Hiwassee River at Reliance, Tenn., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	780	2.4	3,620	4.0	9,300	5.6	16,880
1.0	970	2.6	4,190	4.2	10,190	5.8	17,840
1.2	1,205	2.8	4,800	4.4	11,120	6.0	18,800
1.4	1,485	3.0	5,450	4.6	12,080	6.5	21,200
1.6	1,805	3.2	6,140	4.8	13,040	7.0	23,600
1.8	2,170	3.4	6,870	5.0	14,000	8.0	28,400
2.0	2,600	3.6	7,640	5.2	14,960		
2.2	3,090	3.8	8,450	5.4	15,920		

Estimated monthly discharge of Hiwassee River at Reliance, Tenn.

[Drainage area, 1,180 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	6,870	2,170	3,320	2.81	3.24
February	38,000	2,375	5,729	4.86	5.06
March	20,240	2,840	6,070	5.14	5.92
April	6,140	2,375	3,634	3.08	3.44
May	3,620	1,640	2,205	1.87	2.16
June	1,980	1,205	1,491	1.26	1.41
July	2,375	870	1,239	1.05	1.21
August	1,205	700	875	.74	.85
September	1,980	780	1,054	.89	.99
October	1,640	870	1,034	.88	1.01
November	5,450	870	1,351	1.14	1.27
December	5,790	1,340	2,388	2.02	2.33
The year	38,000	700	2,532	2.14	28.89

NOTTELY RIVER AT RANGER, N. C.

The station was established by Olin P. Hall, on February 16, 1901. It is situated at the Nottely wagon bridge, about one-half mile from Ranger, N. C., on the Murphy division of the Atlanta, Knoxville and Northern Railway. The bridge is an old wooden structure, about 125 feet in length between abutments, and about 20 feet above low water. The bridge is supported on 2 wooden bents, dividing it into 3 spans. The gage is a 1 by 3 inch pine board in two sections, each 8 feet long, graduated to feet and tenths and fastened to the upstream side of the right wooden abutment. The bench mark is the top of the downstream end of the cap of the right abutment; its elevation is 20.05 feet above the zero of the gage. The initial point for sounding is the edge of the right abutment on the downstream side. The observer is A. D. Kilpatrick.

The following discharge measurements were made during 1902:

April 24: Gage height, 4.20 feet; discharge, 598 second-feet.
August 14: Gage height, 2.70 feet; discharge, 213 second-feet.
November 21: Gage height, 2.75 feet; discharge, 213 second-feet.

Daily gage height, in feet, of Nottely River at Ranger, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.50	7.00	9.00	5.00	4.10	3.40	3.00	2.80	2.60	2.90	2.30	3.30
2	5.00	7.00	7.20	5.00	4.00	3.30	2.90	2.80	2.60	2.90	2.60	3.50
3	5.00	9.10	6.10	5.00	4.00	3.30	2.90	3.00	3.00	2.70	2.60	6.20
4	4.50	7.80	6.00	5.00	4.00	3.20	2.80	2.80	3.30	2.70	2.60	4.30
5	4.80	5.50	6.30	5.10	4.00	3.20	2.80	2.80	2.80	2.70	2.50	4.40
6	4.40	5.00	5.80	5.00	4.00	3.20	2.80	2.80	2.60	2.60	2.50	4.30
7	4.40	4.90	5.40	4.80	4.00	3.10	2.80	2.60	2.60	2.60	4.00	4.30
8	4.40	4.90	5.30	4.20	3.70	3.80	2.80	2.60	2.50	2.50	4.00	3.00
9	4.40	4.50	5.20	5.00	3.70	3.60	2.70	2.60	2.70	2.80	2.80	3.00
10	4.30	4.30	5.10	5.00	3.70	3.30	3.00	2.60	2.90	2.70	2.80	3.80
11	4.20	4.20	5.10	5.00	3.70	3.20	3.00	3.80	2.60	3.00	2.70	3.50
12	4.20	4.10	5.00	4.80	3.60	3.10	3.70	3.60	2.50	2.70	2.70	3.40
13	4.00	4.00	6.20	4.40	3.60	3.10	4.40	2.60	3.40	2.90	2.70	3.40
14	3.80	4.00	5.00	4.40	4.70	3.10	3.60	2.60	3.00	3.30	2.50	3.30
15	3.40	4.00	5.00	4.40	4.60	3.10	4.80	2.60	2.80	3.50	2.50	3.30
16	3.40	4.10	6.20	4.40	3.80	3.00	4.30	2.60	2.80	3.00	2.50	5.40
17	3.20	4.00	5.20	4.60	3.70	3.00	4.00	2.60	2.70	2.90	2.40	4.60
18	3.00	4.00	5.80	4.50	3.70	3.00	3.00	2.60	2.70	2.70	3.70	4.60
19	4.00	4.00	5.60	4.40	3.70	3.00	3.00	2.60	3.30	2.90	3.20	3.80
20	4.00	4.00	5.00	4.20	3.60	3.00	3.00	2.60	3.00	2.80	3.00	3.70
21	4.00	4.10	5.00	4.00	3.60	3.30	2.80	2.40	3.00	2.80	2.90	5.40
22	4.00	5.00	4.90	4.10	3.50	3.10	2.80	2.40	2.80	2.70	2.80	5.20
23	3.80	4.50	4.80	4.10	3.40	3.00	2.80	2.40	2.60	2.70	2.80	4.40
24	3.80	4.40	4.70	4.10	3.30	3.00	2.80	2.50	2.60	2.70	2.70	3.80
25	3.80	4.80	4.60	4.10	3.30	3.00	2.70	2.50	2.90	2.60	5.30	3.60
26	3.80	4.60	4.60	4.00	3.30	3.60	2.70	2.70	2.70	2.50	4.40	3.50
27	4.00	4.80	4.70	4.00	3.30	3.60	2.70	3.00	2.00	2.50	3.70	3.60
28	4.40	21.00	4.70	4.00	3.30	3.00	2.70	2.80	3.10	2.50	3.10	3.40
29	4.50	.....	13.80	4.20	3.40	3.00	2.80	2.80	3.00	2.40	3.00	5.20
30	5.00	.....	6.80	4.30	3.40	3.00	2.80	2.70	3.00	2.40	3.00	5.00
31	6.30	.....	5.20	.....	3.40	.....	2.80	2.70	.....	2.30	.....	3.40

Rating table for Nottely River at Ranger, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.4	155	5.2	920	8.0	1,760	12.0	2,960
2.6	190	5.4	980	8.2	1,820	12.5	3,110
2.8	229	5.6	1,040	8.4	1,880	13.0	3,260
3.0	272	5.8	1,100	8.6	1,940	13.5	3,410
3.2	322	6.0	1,160	8.8	2,000	14.0	3,560
3.4	380	6.2	1,220	9.0	2,060	14.5	3,710
3.6	440	6.4	1,280	9.2	2,120	15.0	3,860
3.8	500	6.6	1,340	9.4	2,180	15.5	4,010
4.0	560	6.8	1,400	9.6	2,240	16.0	4,160
4.2	620	7.0	1,460	9.8	2,300	17.0	4,460
4.4	680	7.2	1,520	10.0	2,360	18.0	4,760
4.6	740	7.4	1,580	10.5	2,510	19.0	5,060
4.8	800	7.6	1,640	11.0	2,660	20.0	5,360
5.0	860	7.8	1,700	11.5	2,910	21.0	5,660

Estimated monthly discharge of Nottely River at Ranger, N. C.

[Drainage area, 272 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	1,250	272	631	2.32	2.67
February	5,660	560	1,006	3.70	3.85
March	3,500	740	1,095	4.03	4.64
April	890	560	711	2.61	2.91
May	770	350	475	1.75	2.02
June	500	272	322	1.18	1.32
July	800	209	307	1.13	1.30
August	500	155	219	.81	.93
September	380	172	237	.87	.97
October	410	148	221	.81	.93
November	950	148	295	1.08	1.20
December	1,220	272	576	2.12	2.44
The year	5,660	148	850	1.87	25.18

HIWASSEE RIVER AT MURPHY, N. C.

Hiwassee River rises in the northern part of Georgia and flows through the southwestern corner of North Carolina into Tennessee, where it empties into Tennessee River. The drainage basin is broken and mountainous for the most part and well covered with forest. The station is located at the highway bridge crossing the river at Murphy, N. C., one-half mile above Valley River, and was established by E. W. Myers on July 26, 1896. The length of the gage is 29.10 feet. The section is a fairly good one. The course of the stream is straight for several hundred yards above and below the bridge, and the current fairly rapid. The bottom is hard and rocky and not subject to any decided change. The observer is William Mingus, Murphy, N. C.

Discharge measurements of Hiwassee River at Murphy, N. C.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
August 12	B. S. Drane	4.80	213
August 23	do	4.80	186
September 18	do	4.80	198
Do	E. W. Myers	4.80	216
October 24	B. S. Drane	4.87	260
Do	do	4.90	271

Daily gage height, in feet, of Hiwassee River at Murphy, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.95	7.80	8.50	6.60	5.70	5.30	5.20	4.90	4.75	5.25	4.90	5.65
2	6.60	9.10	7.50	6.50	5.80	5.30	5.20	4.90	4.80	5.15	4.90	5.50
3	6.15	7.50	7.05	6.35	5.70	5.30	5.15	5.20	4.80	5.05	4.90	6.65
4	6.30	6.90	6.80	6.30	5.65	5.25	5.15	4.95	5.15	5.00	4.90	5.95
5	6.15	6.50	7.15	6.25	5.70	5.25	5.15	4.90	4.95	5.05	4.90	5.50
6	6.10	6.35	6.80	6.15	5.70	5.20	5.15	4.85	4.85	5.10	5.90	5.65
7	6.00	6.25	6.55	6.15	5.60	5.20	5.30	4.85	4.80	5.00	5.20	5.50
8	5.95	6.15	6.45	6.65	5.60	5.55	5.15	4.85	4.80	5.00	5.10	5.45
9	5.90	6.50	6.75	6.35	5.60	5.55	5.10	4.80	4.80	5.00	5.00	5.40
10	5.85	6.00	6.55	6.25	5.50	5.55	5.10	4.80	5.35	4.95	5.05	5.35
11	5.85	5.90	6.50	6.15	5.50	5.50	5.10	4.85	4.95	5.00	5.00	5.35
12	5.80	5.90	6.40	6.10	5.55	5.50	5.50	4.80	4.90	5.45	5.00	5.30
13	5.75	5.85	6.65	6.05	5.55	5.50	5.40	4.80	5.05	5.15	5.00	5.35
14	5.70	5.80	6.45	6.00	5.55	5.45	5.25	4.80	5.05	5.45	5.00	5.25
15	5.70	5.85	6.40	6.00	5.50	5.50	5.30	4.85	4.90	5.15	4.95	5.25
16	5.70	5.90	6.45	6.00	5.55	5.50	5.20	4.80	4.90	5.10	4.95	5.75
17	5.65	5.85	6.90	5.95	5.50	5.45	5.15	4.85	4.85	5.05	5.00	6.15
18	5.65	5.75	6.60	6.00	5.55	5.40	5.10	4.80	4.85	5.00	5.50	5.90
19	5.90	5.75	6.45	5.95	5.50	5.40	5.10	4.80	4.95	4.95	5.15	5.65
20	5.70	5.80	6.35	5.90	5.40	5.40	5.05	4.80	5.35	4.95	5.05	5.50
21	5.65	6.05	6.30	5.85	5.40	5.35	5.05	4.80	5.05	4.95	5.05	5.80
22	5.75	6.25	6.25	5.80	5.35	5.40	5.05	4.75	5.00	4.95	5.00	6.30
23	5.65	6.05	6.20	5.80	5.45	5.30	5.05	4.75	4.95	4.95	5.05	5.90
24	5.65	6.00	6.15	5.75	5.40	5.30	5.00	4.75	4.90	4.95	5.00	5.75
25	5.60	6.05	6.10	5.75	5.50	5.25	5.00	4.75	5.45	4.90	5.50	5.70
26	5.60	6.05	6.05	5.75	5.30	5.50	4.95	4.75	5.15	4.90	6.00	5.60
27	5.65	6.00	6.10	5.75	5.30	5.55	4.90	4.85	5.35	4.95	5.70	5.40
28	5.95	14.15	6.10	5.75	5.25	5.45	4.90	4.95	5.45	4.95	5.50	5.45
29	6.05	.....	10.90	5.70	5.25	5.30	4.90	4.90	5.15	4.90	5.40	5.40
30	6.10	.....	7.50	5.90	5.30	5.25	4.90	4.85	5.05	4.90	5.40	5.75
31	7.20	.....	6.90	.....	5.35	.....	4.90	4.90	.....	4.90	.....	5.50

Rating table for Hiwassee River at Murphy, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.3	100	6.2	1,560	8.5	5,700	13.5	14,700
4.4	110	6.4	1,920	9.0	6,600	14.0	15,600
4.6	150	6.6	2,280	9.5	7,500	14.5	16,500
4.8	205	6.8	2,640	10.0	8,400	15.0	17,400
5.0	325	7.0	3,000	10.5	9,300	15.5	18,300
5.2	450	7.2	3,360	11.0	10,200	16.0	19,200
5.4	590	7.4	3,720	11.5	11,100	16.5	20,100
5.6	750	7.6	4,080	12.0	12,000	17.0	21,000
5.8	940	7.8	4,440	12.5	12,900	18.0	22,800
6.0	1,200	8.0	4,800	13.0	13,800	19.0	24,600

Estimated monthly discharge of Hiwassee River at Murphy, N. C.

[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	3,360	750	1,203	2.93	3.38
February	15,870	892	2,259	5.51	5.74
March	10,020	1,290	2,582	6.30	7.26
April	2,370	845	1,331	3.25	3.63
May	940	485	677	1.65	1.90
June	710	100	556	1.36	1.52
July	670	265	363	.89	1.03
August	450	190	232	.57	.66
September	555	190	336	.82	.91
October	485	265	347	.85	.98
November	1,200	265	450	1.10	1.23
December	2,370	520	834	2.03	2.34
The year	15,870	100	931	2.27	30.58

LITTLE TENNESSEE RIVER AT JUDSON, N. C.

This river rises in northern Georgia, with tributaries from the mountains between North Carolina and Georgia, and flows in a northwesterly direction, emptying into Tennessee River at Lenoir, Tenn. Measurements of flow are made at Judson, N. C., below the mouth of Sawyer Branch. The area drained is mountainous and covered with forest growth. The station was established by E. W. Myers in June, 1896. It is located on the Southern Railway bridge, about one-fourth of a mile from Judson, N. C. The river is straight for several hundred yards above and below the station; the bottom rocky and very rough on the west side and sandy on the east side. The current is swift and considerably obstructed by two old piers. The section is constant, but not a good one for measurements. The observer is R. C. Sawyer, a farmer at Judson, N. C.

The following discharge measurements were made during 1902 by B. S. Drane:

August 11: Gage height, 2.50 feet; discharge, 686 second-feet.
August 22: Gage height, 2.50 feet; discharge, 471 second-feet.
October 25: Gage height, 2.62 feet; discharge, 736 second-feet.

Daily gage height, in feet, of Little Tennessee River at Judson, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.41	6.72	7.29	4.92	3.24	3.20	2.91	2.71	2.51	3.00	2.61	3.35
2	6.51	5.38	5.32	4.84	4.61	3.41	2.91	2.71	2.41	2.91	2.71	3.32
3	6.34	4.92	4.96	4.34	3.22	3.31	3.00	2.71	2.41	2.81	2.61	4.90
4	5.28	4.92	4.94	4.31	3.18	3.10	2.81	2.61	2.91	2.71	2.51	3.15
5	4.49	4.91	4.81	4.23	3.10	3.08	3.81	2.61	2.71	2.91	2.61	3.10
6	4.48	4.86	4.81	4.21	4.26	3.05	2.81	2.51	2.51	2.91	4.71	3.74
7	4.48	4.42	4.78	4.19	3.92	3.10	2.81	2.61	2.51	2.81	3.41	3.45
8	4.46	4.50	5.21	4.19	3.17	3.31	2.81	2.51	2.51	2.71	3.00	3.41
9	4.52	4.60	4.19	4.12	2.94	3.10	3.00	2.51	2.81	2.71	2.91	3.35
10	4.51	4.50	4.12	4.90	2.91	3.05	3.00	2.61	2.51	2.61	2.81	3.26
11	4.43	4.20	4.13	4.90	2.93	3.04	3.10	2.51	2.71	2.71	2.81	3.20
12	4.42	4.20	4.13	4.60	2.91	3.03	3.51	2.51	2.61	3.41	2.81	3.35
13	4.39	4.10	4.10	4.80	3.61	3.00	3.31	2.41	2.61	3.00	2.81	3.30
14	4.32	3.98	4.10	4.70	3.71	3.20	2.91	2.51	3.10	3.10	2.71	3.25
15	4.28	3.96	4.12	4.60	3.61	3.20	3.91	2.51	2.71	2.91	2.71	3.15
16	4.24	4.21	5.39	4.30	3.51	3.20	2.81	2.71	2.61	2.81	2.70	3.25
17	4.22	4.28	4.72	4.28	3.51	3.10	2.71	2.71	2.51	2.81	2.76	4.60
18	3.91	4.27	4.68	4.92	3.51	2.91	2.71	2.51	2.51	2.71	2.70	4.00
19	3.92	4.22	4.22	4.61	3.41	3.00	2.81	2.51	2.91	2.71	2.70	3.85
20	3.96	3.93	4.15	5.20	3.41	3.01	3.10	2.41	3.31	2.71	2.80	3.71
21	4.51	3.93	3.96	4.42	3.41	3.31	2.91	2.41	3.00	2.71	2.80	3.75
22	3.68	3.91	3.91	4.19	3.51	3.20	2.70	2.51	2.91	2.61	2.75	4.70
23	3.62	3.86	3.82	4.30	3.41	3.00	2.71	2.51	2.71	2.61	2.86	4.10
24	3.53	4.17	3.82	3.96	3.31	2.91	2.61	2.61	2.71	2.61	2.70	3.95
25	4.21	4.16	3.68	3.91	3.31	2.91	2.61	2.41	4.10	2.61	3.55	3.76
26	4.19	4.19	3.67	3.68	3.31	3.10	2.61	2.51	3.71	2.71	4.30	3.65
27	4.16	5.22	3.54	3.51	3.21	3.20	2.71	2.71	3.31	2.61	3.35	3.27
28	5.91	16.19	4.91	3.10	3.21	3.00	2.61	2.61	3.20	2.71	3.31	3.25
29	5.84	.....	9.32	3.10	3.21	3.10	2.71	2.61	3.40	2.61	3.30	3.50
30	4.36	.....	6.28	2.98	3.20	3.00	2.71	2.51	3.30	2.61	3.20	4.00
31	4.33	.....	5.49	.....	3.20	.....	2.61	2.61	.....	2.61	.....	3.51

Rating table for Little Tennessee River at Judson, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.5	575	3.6	1,860	4.8	3,980	6.0	6,580
2.6	675	3.8	2,140	5.0	4,380	6.2	7,070
2.8	875	4.0	2,460	5.2	4,820	6.4	7,560
3.0	1,100	4.2	2,800	5.4	5,260	6.6	8,050
3.2	1,340	4.4	3,180	5.6	5,700	6.8	8,540
3.4	1,580	4.6	3,580	5.8	6,140	7.0	9,030

Estimated monthly discharge of Little Tennessee River at Judson, N. C.

[Drainage area, 675 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	13,800	1,790	3,827	5.67	6.54
February	50,460	2,220	5,036	7.46	7.77
March	17,550	1,790	4,079	6.04	6.96
April	4,820	1,100	3,032	4.49	5.01
May	3,580	975	1,592	2.36	2.72
June	2,140	975	1,319	1.95	2.18
July	2,300	675	1,010	1.50	1.73
August	775	475	627	.93	1.07
September	2,620	475	964	1.43	1.60
October	1,580	675	846	1.25	1.44
November	3,780	575	1,128	1.67	1.86
December	4,180	1,220	1,939	2.87	3.31
The year	50,460	475	2,117	3.14	42.19

TUCKASEGEE RIVER AT BRYSON, N. C.

This river rises in the southwestern part of North Carolina, at the base of Tennessee Ridge, which separates Jackson and Transylvania counties. It flows in a northwesterly direction, emptying into Little Tennessee River at Bushnell, N. C. Measurements of discharge are made at Bryson, 2 miles below the mouth of Newton Mill Creek. The drainage area is largely rough and mountainous, and covered with forest growth. The old station, described in the Eighteenth Annual Report, part 4, page 116, was on the Southern Railway bridge about 3 miles above Bryson, N. C., and just below Governor Island post-office, and was abandoned March 25, 1897, because the section was poor. A new station was established by A. P. Davis November 7, 1897, at the highway bridge in the town of Bryson, N. C. The gage is bolted to the north pier, lower side, and can be read from the bridge. The initial point of sounding is at the south end of the downstream hand rail. The channel is straight, but obstructed by the remnants of two old piers. The current is sluggish, the river bed muddy and fairly constant. The observer is H. H. Welch, a carpenter at Bryson, N. C.

The following discharge measurements were made during 1902 by B. S. Drane:

August 11: Gage height, 1.05 feet; discharge, 466 second-feet.
August 22: Gage height, 1 foot; discharge, 465 second-feet.
September 17: Gage height, 1 foot; discharge, 520 second-feet.
October 23: Gage height, 1.15 feet; discharge, 546 second-feet.

Daily gage height, in feet, of Tuckasegee River at Bryson, N. C.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.30	3.95	4.90	3.10	2.20	1.90	1.50	1.10	0.95	1.50	1.10	1.80
2	3.00	4.10	4.00	2.90	2.10	1.60	1.40	1.05	0.95	1.30	1.10	1.60
3	2.80	3.20	3.50	2.80	1.90	1.55	1.35	1.20	1.35	1.25	1.10	2.80
4	2.60	2.90	3.20	2.70	1.90	1.50	1.30	1.10	1.20	1.30	1.10	2.20
5	2.40	2.50	3.10	2.60	1.90	1.50	1.40	1.10	1.10	1.35	1.20	2.20
6	2.40	2.50	3.10	2.50	1.90	1.45	1.50	1.40	1.10	1.30	2.50	1.90
7	2.30	2.40	2.90	2.90	1.90	1.50	1.40	1.15	1.00	1.25	1.50	1.80
8	2.25	2.30	3.30	2.70	1.85	1.50	1.30	1.10	1.00	1.20	1.40	1.70
9	2.20	2.10	3.00	2.50	1.80	1.50	1.60	1.05	2.70	1.20	1.30	1.60
10	2.10	2.00	2.90	2.40	1.75	1.40	1.50	1.05	1.70	1.10	1.25	1.60
11	2.05	1.90	2.80	2.40	1.75	1.40	1.40	1.00	1.20	1.30	1.20	1.50
12	2.00	2.00	2.80	2.35	1.75	1.35	1.75	1.00	1.10	1.30	1.20	1.50
13	1.90	1.90	3.20	2.30	1.75	1.40	1.40	1.00	1.50	1.30	1.20	1.50
14	2.00	1.40	2.80	2.25	1.80	1.40	1.30	1.00	1.20	1.75	1.15	1.50
15	1.90	2.00	2.70	2.20	1.75	1.40	1.40	1.00	1.10	1.30	1.15	4.00
16	1.90	2.00	5.25	2.20	1.70	1.60	1.30	1.20	1.10	1.30	1.10	2.10
17	1.80	1.90	3.65	2.35	1.75	1.50	1.25	1.00	1.00	1.25	1.20	2.00
18	1.80	1.80	3.00	2.20	1.70	1.40	1.20	1.00	1.00	1.20	1.50	1.90
19	1.80	1.80	2.90	2.20	2.00	1.40	1.30	1.10	4.00	1.20	1.30	1.80
20	1.80	2.00	2.75	2.20	1.80	1.40	1.30	1.00	2.00	1.20	1.20	1.70
21	1.90	2.20	2.70	2.15	1.80	1.80	1.25	1.00	1.80	1.15	1.20	3.70
22	1.80	2.15	2.60	2.10	1.80	1.45	1.20	1.00	1.20	1.10	1.20	2.30
23	1.75	2.00	2.50	2.00	1.90	1.40	1.20	1.00	1.20	1.10	1.15	2.10
24	1.70	2.00	2.40	2.00	1.75	1.35	1.20	.95	1.40	1.10	1.15	1.90
25	1.65	2.30	2.40	2.00	2.00	1.30	1.10	.90	2.10	1.10	3.45	1.80
26	1.80	2.10	2.30	2.00	1.75	1.60	1.10	1.10	1.70	1.10	2.10	1.70
27	2.40	3.00	2.30	1.95	1.70	1.80	1.10	1.15	1.50	1.10	1.80	1.60
28	2.30	9.90	4.50	1.90	1.65	1.50	1.20	1.10	1.40	1.10	1.60	1.80
29	2.40	.....	6.25	2.10	1.60	1.50	1.20	1.10	1.30	1.10	1.40	1.80
30	3.20	.....	3.90	2.10	1.60	1.70	1.20	1.10	1.40	1.10	1.60	1.80
31	3.80	.....	3.40	.....	1.60	.....	1.10	1.10	.....	1.10	.....	1.60

Rating table for Tuckasegee River at Bryson, N. C., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	400	3.2	4,110	5.4	10,250	7.6	22,480
1.2	600	3.4	4,565	5.6	11,125	7.8	23,640
1.4	830	3.6	5,035	5.8	12,100	8.0	24,800
1.6	1,080	3.8	5,515	6.0	13,200	8.5	27,700
1.8	1,370	4.0	6,000	6.2	14,360	9.0	30,600
2.0	1,700	4.2	6,510	6.4	15,520	9.5	33,500
2.2	2,065	4.4	7,060	6.6	16,680	10.0	36,400
2.4	2,450	4.6	7,640	6.8	17,840	10.5	39,300
2.6	2,850	4.8	8,220	7.0	19,000	11.0	42,200
2.8	3,260	5.0	8,800	7.2	20,160		
3.0	3,675	5.2	9,475	7.4	21,320		

Estimated monthly discharge of Tuckasegee River at Bryson, N. C.

[Drainage area, 662 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	5,515	1,150	2,173	3.28	3.78
February	35,820	830	3,547	5.36	5.58
March	14,650	2,255	4,467	6.75	7.78
April	3,890	1,530	2,341	3.54	3.95
May	2,065	1,080	1,395	2.11	2.43
June	1,530	710	962	1.45	1.62
July	1,295	500	738	1.11	1.28
August	830	300	469	.71	.82
September	6,000	350	1,004	1.52	1.70
October	1,295	500	636	.96	1.11
November	4,682	500	929	1.40	1.56
December	6,000	950	1,723	2.60	3.00
The year	35,820	300	1,699	2.57	34.61

TENNESSEE RIVER AT KNOXVILLE, TENN.

This station was originally established by the United States Weather Bureau at the old county highway bridge, which has been torn down and replaced by a new bridge. Instead of placing the gage at the new bridge, it was decided to move it down the river, in order to get below some shoals and wing dams which have been put in for boating. A temporary gage was put in at the Knoxville and Augusta Railroad bridge, a half mile below the highway bridge, and was used during the greater part of the year 1899. In the latter part of that year a new permanent gage was established, and readings from it began on November 1, 1899. The new gage is on the right bank of the river, just below the mouth of West Knoxville Bayou, and about 1,000 feet below the temporary gage at the Knoxville and Augusta Railroad bridge. The gage, which is graduated to feet and tenths, is in two sections; the first, a sloping section made of a 2 by 4 inch pine timber spiked on top of an 8 by 8 inch oak sill well bolted to piles and embedded in crushed stone, reading from −2 feet to +12 feet; the second, a vertical section of the standard Weather Bureau pattern, with a brass scale, is screwed to one of the bents of the railroad trestle across West Knoxville Bayou, about 50 feet from the bank of the river and from the sloping gage, reading from 12 to 36.5 feet. The gage is fastened to the upstream post of the bent, facing away from the river. The zero of the gage is 804.3 feet above sea level. The bench mark is a

cross in the stone on the east corner of the base to the right-bank pier of the Knoxville and Augusta Railroad bridge, and is 806.7 feet above sea level and 2.4 feet above the zero of the gage. The gage was located for the United States Weather Bureau by the United States Engineer Corps. Daily records are kept by the United States Weather Bureau and are furnished to the Geological Survey. Measurements are made at the Cherokee highway bridge 2 miles below the new gage. This bridge is a three-span iron structure and is about 80 feet above low water. The width of the river at low water is 550 feet. The section is a good one, but the current is rather sluggish at low water.

Professor Fulton, of the Tennessee University, who is Weather Bureau official here, has perfected an attachment which is connected with his office by wire and electrically records the height of water continuously in the same manner that records are made of wind, sunshine, etc.

The following discharge measurements were made during 1902:

August 13: Gage height, 0.69 foot; discharge, 4,710 second-feet.
November 18: Gage height, 0.58 foot; discharge, 4,552 second-feet.

Daily gage height, in feet, of Tennessee River at Knoxville, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	19.00	10.80	34.40	10.80	3.10	1.80	8.00	1.20	0.40	2.00	0.80	1.70
2	11.40	12.20	33.10	7.90	3.00	1.80	6.70	1.20	.30	1.60	.70	1.50
3	8.70	11.80	17.10	7.70	2.90	1.70	4.90	1.80	.40	1.40	.70	2.10
4	7.40	10.20	11.30	6.10	2.60	1.80	3.60	1.60	.50	1.30	.40	2.70
5	6.40	7.90	11.80	5.70	2.50	1.60	2.80	1.20	.70	1.00	.40	3.40
6	5.60	6.30	11.20	6.00	3.00	1.50	2.40	1.00	.80	.90	.50	3.10
7	5.10	5.40	10.30	5.90	2.70	1.40	2.10	1.40	.90	.80	.50	3.30
8	4.70	5.00	8.30	5.50	2.50	1.50	2.10	1.60	.80	1.00	.90	2.90
9	4.50	4.50	8.10	5.60	2.60	1.60	1.90	2.20	.70	1.00	1.00	2.30
10	4.30	3.90	7.80	5.40	2.50	2.20	1.80	1.60	.70	.80	.90	2.00
11	4.00	3.60	7.40	5.00	2.30	2.10	2.10	1.10	1.40	.60	.80	1.80
12	3.80	3.50	6.90	4.70	2.10	1.80	3.30	.90	1.40	.70	.70	1.70
13	3.50	3.40	6.50	4.50	2.00	1.60	3.60	.80	1.20	.80	.60	1.60
14	3.20	3.20	6.10	4.30	2.00	1.40	2.50	.60	.90	1.60	.50	1.50
15	3.00	3.10	5.80	4.10	2.20	1.60	2.40	.60	.80	1.70	.50	1.50
16	3.00	3.00	6.00	4.00	2.20	1.70	2.00	.80	.80	1.50	.50	1.70
17	2.90	2.90	9.30	3.90	2.30	1.80	2.10	1.70	.80	1.30	.40	2.00
18	2.90	2.90	10.60	3.90	2.10	3.30	1.60	1.80	.70	1.00	.50	2.70
19	2.90	2.80	8.70	3.90	2.00	3.60	1.40	1.80	.50	.90	.80	3.10
20	2.80	2.60	7.00	3.80	2.30	3.40	1.30	.70	.80	.70	1.10	2.60
21	3.00	2.80	6.10	3.80	3.00	2.40	1.20	.60	1.80	.60	1.10	2.60
22	3.60	4.00	5.60	3.90	2.90	2.20	1.20	.70	.50	.60	1.00	2.80
23	3.80	4.70	5.10	3.70	3.10	2.40	1.20	.80	1.10	.50	.90	2.80
24	3.40	4.60	4.80	3.50	2.80	2.00	1.00	1.00	.90	.30	.80	2.90
25	3.10	4.20	4.50	3.30	2.60	1.70	.90	.80	1.30	.30	1.40	2.50
26	3.00	5.70	4.20	3.20	2.40	1.50	.80	.60	1.10	.30	2.00	2.00
27	3.90	9.00	4.00	3.00	3.30	1.90	.80	.50	1.90	.30	2.60	1.90
28	8.30	14.80	3.90	2.80	3.30	5.60	.80	.40	1.80	.30	2.80	1.70
29	9.30	.....	10.00	2.80	2.80	9.80	.90	.40	1.60	.40	2.30	1.50
30	8.90	.....	18.50	2.90	2.30	8.60	.90	.40	1.20	.60	1.90	1.40
31	9.60	.....	15.80	.....	2.00	.....	1.20	.40	.....	.80	.....	1.70

Rating table for Tennessee River at Knoxville, Tenn., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	3,500	3.8	15,398	7.6	32,790	16.5	74,175
.2	3,900	4.0	16,242	7.8	33,720	17.0	76,500
.4	4,250	4.2	17,102	8.0	34,650	17.5	78,825
.6	4,590	4.4	17,978	8.5	36,975	18.0	81,150
.8	5,050	4.6	18,870	9.0	39,300	18.5	83,475
1.0	5,600	4.8	19,778	9.5	41,625	19.0	85,800
1.2	6,170	5.0	20,700	10.0	43,950	19.5	88,125
1.4	6,760	5.2	21,630	10.5	46,275	20.0	90,450
1.6	7,370	5.4	22,560	11.0	48,600	21.0	95,100
1.8	8,000	5.6	23,490	11.5	50,925	22.0	99,750
2.0	8,650	5.8	24,420	12.0	53,250	23.0	104,400
2.2	9,320	6.0	25,350	12.5	55,575	24.0	109,050
2.4	10,010	6.2	26,280	13.0	57,900	25.0	113,700
2.6	10,720	6.4	27,210	13.5	60,225	26.0	118,350
2.8	11,450	6.6	28,140	14.0	62,550	27.0	123,000
3.0	12,200	6.8	29,070	14.5	64,875	28.0	127,650
3.2	12,970	7.0	30,000	15.0	67,200	29.0	132,300
3.4	13,760	7.2	30,930	15.5	69,525	30.0	136,950
3.6	14,570	7.4	31,860	16.0	71,850	31.0	141,600

Estimated monthly discharge of Tennessee River at Knoxville, Tenn.

[Drainage area, 8,990 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	85,800	11,450	23,144	2.57	2.96
February	66,270	10,720	24,500	2.73	2.84
March	157,410	15,818	43,999	4.89	5.64
April	47,670	11,450	19,652	2.19	2.44
May	13,362	8,650	10,620	1.18	1.36
June	43,020	6,760	10,952	1.22	1.36
July	34,650	5,050	10,023	1.11	1.28
August	9,320	4,250	5,818	.65	.75
September	8,322	4,100	5,569	.62	.69
October	8,650	4,100	5,425	.60	.69
November	11,450	4,250	5,763	.64	.71
December	13,760	6,760	9,500	1.06	1.22
The year	157,410	4,100	14,580	1.62	21.94

FRENCH BROAD RIVER AT OLDTOWN, NEAR NEWPORT, TENN.

This was originally one of the temporary stations established in connection with the general hydrographic study of the southern Appalachian region.

The original gage put in at this station was carried away with the old bridge by flood early in the spring of 1902. The present gage was put in on the new bridge October 27, 1902. A 12-foot scale, subdivided into feet and tenths, is marked with tacks on the downstream guard rail on the second span from the southwest end. The zero of the gage is directly opposite the center of the first intermediate post, second span from the southwest end. From the zero of the gage to the outer rim of the pulley is 2.80 feet. The length of the wire, from the end of the weight to the pointer, is 30.38 feet. When the gage reads 1 foot the water surface is 25.60 feet below the top of the hexagonal nut on the center bolt in the lower chord of the bridge below (and slightly downstream from) the zero of the gage.

The following discharge measurements were made during 1902 by B. S. Drane:

September 20: Gage height, 3.54 feet; discharge, 4,581 second-feet.
October 27: Gage height, 1.49 feet; discharge, 1,128 second-feet.
November 11: Gage height, 1.57 feet; discharge, 1,299 second-feet.
December 9: Gage height, 2.05 feet; discharge, 2,459 second-feet.

Daily gage height, in feet, of French Broad River at Oldtown, Tenn.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1	1.40	2.10	12	1.40	1.90	23	1.60	2.50
2	1.40	2.20	13	1.50	1.90	24	1.60	2.60
3	1.40	2.30	14	1.40	1.90	25	2.00	2.40
4	1.40	3.20	15	1.40	1.90	26	2.20	2.20
5	1.40	2.80	16	1.50	2.00	27	2.10	2.00
6	1.60	2.60	17	1.60	3.00	28	1.90	2.10
7	1.80	2.40	18	1.60	2.90	29	1.90	2.00
8	2.00	2.30	19	1.90	2.30	30	2.00	1.90
9	1.20	2.20	20	1.80	2.20	31		2.00
10	1.30	2.10	21	1.70	2.10			
11	1.30	2.00	22	1.60	2.20			

PIGEON RIVER AT NEWPORT, TENN.

This station was established September 4, 1900, on the wagon bridge at the upper end of the town of Newport, about 100 yards above the railroad bridge. The course of the river is straight for several hundred yards above and for about 50 yards below the bridge. The current at extreme low water is very sluggish. At even the lowest gage heights the water is very deep. The bottom is smooth, being of rock, in many places overlain with mud. The 15-foot mark of the rod, or the end, is abutted firmly against the east side of the first strut from

the west end of the bridge on the downstream side. The distance between the zero of the rod and the outer rim of the pulley wheel is 0.95 foot, and from the end of the weight to the pointer on the wire the distance is 32.89 feet. When the gage reading is 1 foot, the water level is 27.42 feet below the top surface of the lower chord directly beneath the zero of the gage rod. The rod is of hard pine, well painted, and divided into feet and tenths. The drainage area is 655 square miles. The observer is H. M. Boyer, proprietor of a livery stable at Newport. The records at this station have been incomplete, as the gage has been damaged a number of times by high water and by malicious persons. It was finally reestablished on September 19, 1902, all the measurements for the setting of the gage, etc., being the same as before. Gage heights were not taken until December 14, 1902.

NOLICHUCKY RIVER NEAR CHUCKY VALLEY, TENN.

This station was established September 6, 1900, to aid in the general investigation of the hydrographic conditions of the southern Appalachian region made during the summer and autumn of 1900, and was located on the highway bridge about 1 mile above Chucky Valley post-office.

The wire gage was suspended from the upstream side of the bridge, and the stage of the water surface was referred to a horizontal gage fastened to the guard rail of the bridge. The initial point for sounding was the end of the guard rail at the left end of the bridge, on the downstream side.

The section presented at this point was very favorable for the making of accurate measurements of discharge, as the course of the river was straight for a long distance above and below the station, the bed of the stream was very smooth, the current velocity neither excessive nor too small, and the banks high and not subject to overflow.

This station was maintained until the great flood of May 1901, swept away the bridge, which has not since been replaced.

Discharge measurements of Nolichucky River near Chucky Valley, Tenn.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
September 5	E. W. Myers	2.00	302
September 20	L. V. Branch	2.18	442
October 15	do	2.00	378
November 10	do	2.90	919
1901.			
March 31	R. E. Shuford	5.18	5,356
April 14	E. W. Myers	4.45	3,022

Daily gage height, in feet, of Nolichucky River near Chucky Valley, Tenn.

Day.	Sept.	Oct.	Nov.	Dec.	Day	Sept.	Oct.	Nov.	Dec.
1900.					1900.				
1	.....	1.80	2.50	3.10	17	3.10	2.00	2.50	2.70
2	.....	1.90	2.60	3.20	18	2.60	1.90	2.50	2.70
3	.....	1.90	3.00	3.00	19	2.30	2.00	2.40	2.60
4	.....	2.00	5.20	4.80	20	2.10	1.90	2.40	2.60
5	2.00	3.30	4.00	3.30	21	2.00	1.90	2.30	2.90
6	2.00	3.20	3.50	3.50	22	2.00	1.90	2.50	2.80
7	2.00	2.50	3.20	3.40	23	2.20	9.30	2.50	2.90
8	2.00	2.30	2.50	3.30	24	2.20	5.20	2.50	3.00
9	1.80	2.30	3.00	3.30	25	2.10	3.90	2.70	3.00
10	1.80	2.20	2.90	3.20	26	2.10	3.30	6.50	3.20
11	1.80	2.10	2.80	3.10	27	2.10	3.10	4.50	3.10
12	1.80	2.10	2.80	3.00	28	2.00	2.90	3.40	3.00
13	1.80	2.10	2.70	3.00	29	2.00	2.80	3.40	2.90
14	2.60	2.00	2.70	2.90	30	1.80	2.70	3.20	3.00
15	2.30	2.00	2.60	2.90	31	.....	2.60	.....	3.20
16	4.70	2.00	2.50	2.80					

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1901.						1901.					
1	3.20	3.20	3.10	4.10	4.30	17	3.70	3.30	3.30	3.20	3.30
2	3.30	3.00	2.80	6.80	4.10	18	3.50	3.40	3.20	3.10	3.30
3	3.50	3.30	2.80	8.60	4.10	19	3.20	3.20	3.10	3.20	3.40
4	3.30	3.20	2.80	6.40	4.80	20	3.30	3.30	3.30	4.60	3.40
5	3.10	3.30	3.30	5.30	4.00	21	3.40	3.30	3.30	3.40	3.50
6	3.00	3.30	3.20	4.90	3.80	22	3.20	3.30	3.40	3.30	.....
7	3.00	3.40	2.90	4.70	3.60	23	3.50	3.40	3.40	3.30	.....
8	3.20	3.40	3.00	4.60	3.60	24	3.30	3.20	3.20	3.40	.....
9	3.00	4.00	3.30	4.40	4.00	25	3.30	3.40	3.30	3.80	.....
10	2.90	4.20	3.30	4.20	3.80	26	3.20	3.30	8.00	4.40	.....
11	3.00	3.90	4.70	4.00	3.80	27	3.20	3.20	5.30	4.50	.....
12	3.60	3.80	3.80	3.80	3.70	28	3.30	3.20	5.30	4.40	.....
13	5.20	3.60	3.50	3.00	3.60	29	3.30	.....	4.50	4.50	.....
14	4.30	3.40	3.30	3.20	3.50	30	3.20	.....	4.60	4.40	.....
15	4.00	3.30	3.30	3.10	3.40	31	3.30	.....	4.40	.....	.....
16	3.90	3.40	3.40	3.20	3.40						

Rating table for Nolichucky River near Chucky Valley, Tenn., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.8	270	4.4	2,925	7.0	12,650	9.6	23,050
1.9	305	4.5	3,150	7.1	13,050	9.7	23,450
2.0	340	4.6	3,400	7.2	13,450	9.8	23,850
2.1	390	4.7	3,675	7.3	13,850	9.9	24,250
2.2	440	4.8	3,950	7.4	14,250	10.0	24,650
2.3	500	4.9	4,300	7.5	14,650	10.1	25,050
2.4	560	5.0	4,650	7.6	15,050	10.2	25,450
2.5	625	5.1	5,050	7.7	15,450	10.3	25,850
2.6	695	5.2	5,450	7.8	15,850	10.4	26,250
2.7	765	5.3	5,850	7.9	16,250	10.5	26,650
2.8	840	5.4	6,250	8.0	16,650	10.6	27,050
2.9	920	5.5	6,650	8.1	17,050	10.7	27,450
3.0	1,000	5.6	7,050	8.2	17,450	10.8	27,850
3.1	1,085	5.7	7,450	8.3	17,850	10.9	28,250
3.2	1,175	5.8	7,850	8.4	18,250	11.0	28,650
3.3	1,275	5.9	8,250	8.5	18,650	11.1	29,050
3.4	1,385	6.0	8,650	8.6	19,050	11.2	29,450
3.5	1,505	6.1	9,050	8.7	19,450	11.3	29,850
3.6	1,630	6.2	9,450	8.8	19,850	11.4	30,250
3.7	1,770	6.3	9,850	8.9	20,250	11.5	30,650
3.8	1,910	6.4	10,250	9.0	20,650	11.6	31,050
3.9	2,060	6.5	10,650	9.1	21,050	11.7	31,450
4.0	2,210	6.6	11,050	9.2	21,450	11.8	31,850
4.1	2,370	6.7	11,450	9.3	21,850	11.9	32,250
4.2	2,540	6.8	11,850	9.4	22,250	12.0	32,650
4.3	2,725	6.9	12,250	9.5	22,650		

Estimated monthly discharge of Nolichucky River near Chucky Valley, Tenn.

[Drainage area, 817 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	Inches.
1900.							
September [a]			536	27,642	0.656	0.63	3.08
October	21,850	270	1,444	88,788	1.767	2.04	5.33
November	10,650	500	1,433	85,270	1.754	1.96	3.89
December	3,950	695	1,173	72,125	1.435	1.65	3.40
1901.							
January	5,450	920	1,490	91,617	1.823	2.09	3.84
February	2,540	1,000	1,413	78,474	1.729	1.81	2.03
March	16,650	840	2,280	140,192	2.790	3.22	4.37
April	19,050	1,000	3,457	205,706	4.231	4.75	5.12
May [b]			1,868	77,807	2.286	1.79	6.92

[a] 26 days.

[b] May 1 to 21. Does not include great May flood, which washed bridge and gage away.

Note on rainfall for May, 1901: This does not contain any record from station in mountains of North Carolina for this month, where the rainfall was very great from May 18 to 23, causing greatest floods ever known in most of the rivers draining the region.

HOLSTON RIVER (SOUTH FORK) AT BLUFF CITY, TENN.

This station was originally established by the United States Weather Bureau at the highway bridge at Bluff City. Readings were begun July 17, 1900, by the United States Geological survey, in connection with the general hydrographic investigation of the southern Appalachian region. The gage is a 4 by 8 inch timber, bolted to the downstream side of the stone pier. The initial point for soundings is on the north end of the bridge, downstream side. The channel is straight for about 500 feet above and below the bridge, and the current is swift. The north bank is high, but the south bank is subject to overflow at the bridge. The bed is rocky and constant in section. O. V. Cox is the observer.

The following discharge measurements were made during 1902 by B. S. Drane:

October 28: Gage height, 0.45 foot; discharge, 460 second-feet.
November 12: Gage height, 0.35 foot; discharge, 355 second-feet.
December 10: Gage height, 1.10 feet; discharge, 789 second-feet.

Daily gage height, in feet, of Holston River (South Fork) at Bluff City, Tenn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.50	5.40	8.20	3.10	1.30	0.70	4.10	1.10	0.40	1.00	0.30	1.20
2	3.40	4.60	6.70	2.60	1.20	.70	3.20	1.10	.30	.60	.30	1.00
3	3.30	3.70	6.50	2.30	1.10	.60	2.10	1.10	.30	.40	.40	.90
4	3.20	3.80	5.40	2.40	1.10	.50	2.10	1.10	.40	.50	.40	1.70
5	3.00	3.70	4.70	3.30	1.10	.50	1.60	1.00	.50	.70	.40	2.20
6	2.80	2.80	4.50	3.00	1.00	.50	1.60	4.00	.50	.60	.40	2.70
7	2.70	2.60	4.10	2.80	1.00	.40	1.20	3.10	.60	.50	.30	1.70
8	2.60	2.00	3.40	2.60	1.00	1.00	1.40	2.80	.50	.40	.30	1.30
9	2.40	1.80	3.30	2.40	.90	1.40	1.50	1.30	.30	.30	.30	1.20
10	2.00	1.80	3.30	2.50	.90	1.00	1.70	1.00	.40	.20	.30	1.10
11	1.20	1.70	3.20	2.40	.90	.60	1.40	1.30	.40	.20	.30	1.00
12	1.20	1.70	3.10	2.40	.90	.60	1.30	1.00	.40	.70	.30	.90
13	1.10	1.60	3.10	2.30	.90	1.00	1.20	1.00	.40	.70	.30	1.00
14	1.60	1.60	3.10	2.20	.90	1.50	1.60	1.00	.30	.60	.30	.90
15	1.50	1.70	2.80	2.00	.90	1.20	.90	.90	.30	.60	.30	.90
16	1.30	1.60	3.40	1.80	.90	1.10	.80	.80	.30	.60	.30	1.30
17	1.30	1.50	3.40	1.60	.90	2.00	.80	.80	.20	.50	.30	1.70
18	1.30	1.50	3.10	1.40	.90	1.50	.70	.70	.20	.40	.40	1.60
19	1.20	1.40	2.80	1.40	.90	1.20	.70	.90	.20	.40	.40	1.30
20	1.70	1.40	2.70	1.40	.90	1.10	.70	.90	.40	.30	.50	1.30
21	1.60	2.00	2.30	1.90	1.00	1.00	.90	1.00	.30	.20	.40	1.20
22	1.50	2.00	2.00	1.80	.90	.90	.80	.90	.20	.20	.40	1.10
23	1.70	1.80	2.80	1.70	.80	.80	.70	.80	.20	.10	.50	1.00
24	1.80	2.00	2.70	1.60	.80	.70	.70	.70	.10	.10	.50	.90
25	1.70	2.60	2.00	1.50	1.10	.60	.70	.70	.20	.10	.70	.90
26	1.80	3.10	1.80	1.40	1.10	1.20	.70	.60	.70	.10	1.60	.80
27	3.60	4.40	1.80	1.30	1.10	5.55	.70	.60	.40	.50	1.60	.70
28	3.40	11.45	2.00	1.30	.90	8.00	.80	.50	.40	.40	1.60	.80
29	4.40	.....	6.00	1.20	.90	4.40	.90	.40	.40	.40	1.40	.90
30	4.80	.....	5.00	1.40	.80	4.20	1.80	.40	.60	.30	1.30	1.10
31	5.40	.....	3.80	.....	.80	.....	1.20	.40	.....	.30	.....	1.00

Rating table for Holston River (South Fork) at Bluff City, Tenn., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	293	2.2	1,890	4.4	4,430	7.5	16,400
.2	310	2.4	2,110	4.6	4,795	8.0	18,500
.4	346	2.6	2,330	4.8	5,245	9.0	22,700
.6	444	2.8	2,550	5.0	5,900	10.0	26,900
.8	576	3.0	2,770	5.2	6,740	11.0	31,100
1.0	730	3.2	2,990	5.4	7,580	12.0	35,300
1.2	896	3.4	3,210	5.6	8,420	13.0	39,500
1.4	1,070	3.6	3,430	5.8	9,260	14.0	43,700
1.6	1,255	3.8	3,650	6.0	10,100		
1.8	1,456	4.0	3,870	6.5	12,200		
2.0	1,670	4.2	4,130	7.0	14,300		

Estimated monthly discharge of Holston River (South Fork) at Bluff City, Tenn.

[Drainage area, 828 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	7,580	813	2,256	2.72	3.14
February	32,990	1,070	3,356	4.05	4.22
March	19,340	1,456	4,459	5.39	6.21
April	3,100	896	1,730	2.09	2.33
May	983	576	702	.85	.98
June	18,500	346	1,788	2.16	2.41
July	4,000	510	1,692	2.04	2.35
August	3,870	346	874	1.06	1.22
September	510	293	349	.42	.47
October	730	293	383	.46	.53
November	1,255	328	485	.59	.66
December	2,440	510	922	1.11	1.28
The year	32,990	293	1,583	1.91	25.80

WATAUGA RIVER AT BUTLER, TENN.

This station was established on August 14, 1900, in connection with the general hydrographic investigation of the southern Appalachian area.

The gage rod was a vertical scale graduated to feet and tenths and securely spiked and braced to an overhanging tree on the right bank of the stream about 100 yards below the highway bridge, from which the gagings were made and on which was the bench mark to which the gage was referred.

The section at this station was favorable for making accurate measurements of discharge, as the bed of the stream was of smooth, hard sand, the course of the river straight for some distance above and below the station, and the current velocities sufficient and well distributed in the section, while the banks were high and not subject to overflow except during extraordinary freshets.

The initial point for soundings was at the end of the hand rail on the left bank of the stream and on the downstream side of the bridge.

This station was maintained up to the end of 1901, though the bridge from which gagings were made was swept away in the great flood of May, 1901, and no gagings were possible after that date.

Discharge measurements of Watauga River at Butler, Tenn.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 30	E. W. Myers	1.37	434
August 7	L. V. Branch	.90	214
August 17	do	.84	166
October 6	E. W. Myers	1.12	238
November 7	L. V. Branch	2.20	591
December 28	E. W. Myers	1.40	311
1901.			
January 17	E. W. Myers	2.10	574
April 12	do	2.55	849

Daily gage height, in feet, of Watauga River at Butler, Tenn.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept	Oct.	Nov.	Dec.
1900.						1900.					
1	.....	0.90	0.90	5.60	2.00	17	.....	4.50	0.70	1.50	1.50
2	.....	.90	.90	5.00	2.40	18	0.90	4.00	.70	1.50	1.50
3	.....	.90	.90	2.30	2.40	19	.80	3.20	.70	1.40	1.50
4	.....	.90	.90	2.10	5.00	20	.80	2.70	.70	1.40	1.50
5	.....	.90	.90	2.50	4.00	21	1.10	1.10	.70	1.40	1.50
6	.....	.90	.90	2.30	3.50	22	1.60	1.00	.70	1.40	1.50
7	.....	.80	.90	2.00	3.00	23	1.30	1.10	15.00	1.40	1.50
8	.....	.80	.90	2.00	2.50	24	1.20	.90	9.00	1.40	1.50
9	.....	.80	.90	1.90	2.10	25	.90	.90	4.50	1.40	1.50
10	.....	.80	.90	1.90	1.90	26	.90	.90	2.50	5.40	1.50
11	.....	.80	.90	1.90	1.50	27	.90	.90	2.00	4.00	1.50
12	.....	.80	.80	1.80	1.50	28	90	.90	4.50	3.00	1.50
13	.....	.80	.80	1.60	1.50	29	.80	.90	4.00	3.00	1.50
14	1.30	1.70	.90	1.50	1.50	30	1.90	90	4.00	2.40	1.50
15	.80	1.70	.80	1.50	1.50	31	1.40	.....	3.20	.....	1.50
16	.70	3.10	.70	1.50	1.50						

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	2.00	1.60	1.50	3.00	3.00	3.00	6.40	2.00	3.50	2.80	2.60	2.60
2	2.00	1.60	1.50	8.00	3.00	3.00	4.10	2.00	3.10	2.80	2.60	2.60
3	2.00	1.60	1.50	7.00	3.00	3.00	3.50	2.00	2.70	2.80	2.60	2.60
4	1.80	2.80	1.50	6.30	3.00	3.00	2.80	2.00	2.70	2.80	3.50	2.60
5	1.60	2.00	1.50	5.00	3.00	3.00	2.50	2.00	2.70	2.80	3.10	2.60
6	1.50	2.00	1.50	4.50	3.00	3.00	2.50	8.00	2.70	2.80	3.00	2.60
7	1.50	1.80	1.70	3.40	3.60	3.00	2.50	5.10	2.70	2.70	2.80	2.60
8	1.50	1.60	2.00	3.00	4.60	11.00	2.30	3.40	2.70	2.70	2.80	2.60
9	1.50	3.50	2.00	2.50	3.50	6.30	2.00	2.80	2.70	2.60	2.80	2.60
10	1.90	3.00	2.00	2.50	3.20	4.50	2.00	2.50	2.70	2.60	2.80	4.70
11	2.00	2.80	4.00	2.50	.....	4.50	2.00	3.50	2.70	2.60	2.80	3.60
12	7.00	2.80	3.00	2.50	2.80	3.60	2.00	7.60	3.00	2.60	2.80	3.10

Daily gage height, in feet, of Watauga River at Butler, Tenn.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
13	5.00	2.40	2.00	2.50	2.80	3.40	2.00	5.30	3.00	4.10	2.80	3.00
14	4.30	2.00	2.00	2.50	2.60	3.00	2.00	4.50	2.70	4.00	2.80	9.50
15	3.60	2.00	2.00	2.50	2.60	3.00	2.00	4.70	2.70	3.60	2.80	8.00
16	3.00	2.00	2.00	2.50	2.60	3.00	2.00	6.70	4.50	3.60	2.80	6.00
17	2.60	2.00	2.00	2.50	2.60	2.50	2.00	6.70	3.60	3.20	2.80	4.50
18	2.60	1.80	2.00	2.50	2.60	2.50	2.00	5.90	3.10	3.20	2.80	3.60
19	2.60	1.60	1.80	2.50	2.80	2.50	2.00	4.60	3.00	3.20	2.80	3.00
20	2.10	1.00	1.60	12.00	3.00	2.50	2.00	4.00	3.00	3.20	2.80	3.00
21	2.00	.80	1.60	5.20	16.27	2.50	2.00	6.90	3.00	3.20	2.80	3.00
22	1.80	.80	1.60	4.50	11.00	2.50	2.00	5.80	3.00	3.20	2.80	3.00
23	1.60	.60	1.60	4.50	5.00	2.50	2.00	4.00	3.00	2.90	2.80	3.00
24	1.60	.60	1.80	4.50	4.60	2.50	2.00	3.50	3.80	2.90	2.60	6.00
25	1.60	.80	2.00	3.70	4.50	2.50	2.00	3.50	3.50	2.90	2.60	4.00
26	1.60	1.00	7.00	3.70	3.60	3.20	2.00	3.50	3.00	2.90	2.60	3.00
27	1.60	1.50	6.00	3.70	3.40	8.70	2.00	3.50	3.00	2.60	2.60	3.00
28	1.60	1.50	4.80	3.00	3.40	8.90	2.00	3.50	3.00	2.60	2.60	3.00
29	1.60	.....	3.50	3.00	3.40	3.80	2.00	3.50	3.00	2.60	2.60	.....
30	1.60	.....	3.00	3.00	3.40	2.60	2.00	3.50	2.80	2.60	2.60	.....
31	1.60	.....	3.00	.....	3.00	.....	2.00	3.50	.....	2.60	.....	.....

Rating table for Watauga River at Butler, Tenn., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	120	2.3	665	4.0	2,010	5.7	3,370
.7	135	2.4	735	4.1	2,090	5.8	3,450
.8	157	2.5	810	4.2	2,170	5.9	3,530
.9	180	2.6	890	4.3	2,250	6.0	3,610
1.0	205	2.7	970	4.4	2,330	6.1	3,690
1.1	230	2.8	1,050	4.5	2,410	6.2	3,770
1.2	255	2.9	1,130	4.6	2,490	6.3	3,850
1.3	283	3.0	1,210	4.7	2,570	6.4	3,930
1.4	311	3.1	1,290	4.8	2,650	6.5	4,010
1.5	341	3.2	1,370	4.9	2,730	6.6	4,090
1.6	373	3.3	1,450	5.0	2,810	6.7	4,170
1.7	405	3.4	1,530	5.1	2,890	6.8	4,250
1.8	440	3.5	1,610	5.2	2,970	6.9	4,330
1.9	476	3.6	1,690	5.3	3,050	7.0	4,410
2.0	515	3.7	1,770	5.4	3,130		
2.1	562	3.8	1,850	5.5	3,210		
2.2	610	3.9	1,930	5.6	3,290		

Estimated monthly discharge of Watauga River at Butler, Tenn

[Drainage area, 261 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
August [a]	.....	.....	228	7,688	0.874	0.25
September	2,410	157	432	25,705	1.655	1.85
October	10,810	135	1,030	63,332	3.946	4.55
November	3,290	311	808	48,079	3.097	3.46
December	2,810	341	601	36,953	2.302	2.65
1901.						
January	4,410	341	794	48,820	3.042	3.52
February	1,610	120	512	28,435	1.962	2.04
March	4,410	341	900	55,339	3.448	3.97
April	8,410	810	1,970	117,223	7.548	8.42
May	11,850	890	1,971	121,192	7.551	8.71
June	7,610	810	1,821	108,357	6.977	7.78
July	3,930	515	762	46,853	2.920	3.37
August	5,210	515	2,182	134,166	8.360	9.63
September	2,410	970	1,226	75,332	4.697	5.24
October	2,090	890	1,176	72,309	4.505	5.20
November	1,610	890	969	57,659	3.712	4.14
December [b]	.....	.....	1,762	97,801	6.751	8.93
The year	11,850	120	1,337	963,486	5.123	70.95

[a] 17 days. [b] 28 days.

ROAN CREEK AT BUTLER, TENN.

The station on this stream was established on August 8, 1900, and the gage rod was spiked and braced to a tree on the left bank of the stream a short distance below Cole & Scott's gristmill, about one-half mile above the mouth of the creek, at which point the gagings were made from the highway bridge. The initial point for soundings at this station was at the end of the hand rail over the right bank and on the upstream side of the bridge. The left bank was low and subject to overflow, and the bed was of sand and mud.

The bridge on which this station was located was washed away at the same time as the one across the Watauga, but was later replaced by a temporary structure, from which a gaging was made near the end of 1901.

This station was discontinued at the end of 1901.

Discharge measurements of Roan Creek at Butler, Tenn.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 30	E. W. Myers	1.47	137
August 7	do	1.02	65
August 17	do	.85	58
October 6	do	.86	52
November 7	do	1.50	171
December 28	do	1.20	82
1901.			
January 17	do	1.72	279
April 12	do	1.70	286
October 25	do	.95	118

Daily gage height, in feet, of Roan Creek at Butler, Tenn.

Day.	Aug.	Sept.	Oct.	Day.	Aug.	Sept.	Oct.
1900.				1900.			
1	.....	0.95	1.00	17	0.84	1.30	0.80
2	.....	1.00	.85	18	.85	1.05	.80
3	.....	.83	.85	19	.80	1.00	.80
4	.....	.88	.85	20	.82	.93	.81
5	.....	.83	.80	21	1.05	.92	.78
6	.....	.81	.86	22	1.71	.95	.80
7	.....	.80	.80	23	1.27	1.20	4.80
8	0.90	.76	.83	24	1.00	1.25	.....
9	.72	.80	.89	25	.90	1.05	.....
10	.82	.75	.88	26	.90	.95	.....
11	.78	.75	.83	27	.84	.98	.....
12	.78	.73	.87	28	.86	.91	.....
13	.85	.75	.90	29	.91	.95	.....
14	1.20	1.00	.85	30	1.32	1.30	.....
15	.93	1.65	.88	31	1.05	.....	.....
16	.86	2.50	.82				

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1901.										
1	1.60	1.20	1.90	1.80	.....	.....	.....	6.60	1.50	0.80
2	1.50	1.20	3.30	1.90	.....	.....	.....	4.10	1.50	.85
3	1.60	1.20	6.25	1.80	.....	.....	.....	3.00	1.50	.90
4	1.60	1.20	.....	1.70	.....	.....	.....	2.20	1.40	.90
5	1.80	1.30	.....	1.70	.....	.....	2.80	1.90	1.40	.80
6	1.90	1.30	.....	1.50	.....	.....	3.90	1.60	1.20	.80
7	2.20	1.40	.....	1.40	.....	.....	3.30	1.60	1.10	.80
8	2.00	1.30	.....	1.40	.....	.....	3.00	1.60	1.10	.80
9	1.80	1.20	.....	1.60	.....	.....	1.80	1.60	1.10	.75
10	1.80	1.20	.....	1.60	.....	.....	1.50	1.50	1.00	.80
11	1.40	1.30	.....	1.60	.....	.....	2.00	1.40	1.00	.80
12	1.60	1.25	1.20	1.60	.....	.....	3.05	1.45	1.20	.80

Daily gage height, in feet, of Roan Creek at Butler, Tenn.—Continued.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1901.										
13	1.60	1.30	1.60	1.90	.....	.....	5.00	1.35	1.90	0.90
14	1.60	1.40	1.60	1.80	.....	.....	4.50	1.30	1.70	.90
15	1.50	1.70	1.60	1.80	.....	.....	4.00	1.20	1.40	.95
16	1.40	1.50	1.50	1.70	.....	.....	4.00	1.30	1.40	.90
17	1.40	1.50	1.50	1.60	.....	.....	3.40	1.60	1.20	.90
18	1.40	1.30	1.45	1.40	.....	.....	3.00	1.50	1.10	.90
19	1.40	1.30	1.40	1.90	.....	.....	2.60	1.30	1.10	.80
20	1.30	1.30	6.45	7.60	.....	.....	4.45	1.30	1.10	.80
21	1.30	1.30	3.60	.....	.....	.....	4.40	1.20	1.00	.80
22	1.30	1.30	3.00	.....	.....	.....	3.00	1.20	1.00	.80
23	1.30	1.40	2.80	.....	.....	.....	2.60	1.15	1.00	1.00
24	1.40	1.30	2.50	.....	.....	.....	2.50	1.10	1.00	.....
25	1.45	1.30	3.20	.....	.....	.....	1.80	1.10	.95	.....
26	1.30	3.35	3.30	.....	.....	.....	2.20	1.00	.90	.....
27	1.30	3.30	2.60	.....	.....	.....	2.80	1.00	.80	.....
28	1.25	3.00	2.30	.....	.....	.....	2.40	1.00	.80	.....
29	.....	2.80	2.00	.....	.....	.....	2.00	1.80	.85	.....
30	.....	2.40	1.80	.....	.....	.....	2.00	1.60	.80	.....
31	.....	2.10	.....	.....	.....	.....	2.00	.....	.80	.....

Rating table for Roan Creek at Butler, Tenn., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	35	2.3	720	4.0	1,995	5.7	3,270
.7	42	2.4	795	4.1	2,070	5.8	3,345
.8	50	2.5	870	4.2	2,145	5.9	3,420
.9	61	2.6	945	4.3	2,220	6.0	3,495
1.0	73	2.7	1,020	4.4	2,295	6.1	3,570
1.1	87	2.8	1,095	4.5	2,370	6.2	3,645
1.2	102	2.9	1,170	4.6	2,445	6.3	3,720
1.3	120	3.0	1,245	4.7	2,520	6.4	3,795
1.4	143	3.1	1,320	4.8	2,595	6.5	3,870
1.5	170	3.2	1,395	4.9	2,670	6.6	3,945
1.6	210	3.3	1,470	5.0	2,745	6.7	4,020
1.7	270	3.4	1,545	5.1	2,820	6.8	4,095
1.8	345	3.5	1,620	5.2	2,895	6.9	4,170
1.9	420	3.6	1,695	5.3	2,970	7.0	4,245
2.0	495	3.7	1,770	5.4	3,045		
2.1	570	3.8	1,845	5.5	3,120		
2.2	645	3.9	1,920	5.6	3,195		

Estimated monthly discharge of Roan Creek at Butler, Tenn.

[Drainage area, 164 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
August [a]			74	3,522	0.45	0.40
September	870	46	101	6,009	.677	.75
October [b]			165	7,527	1.010	.86
1901.						
February	645	111	216	11,996	1.323	1.38
March	1,507	102	319	19,614	1.945	2.25
April [c]			957	41,760	5.835	7.62
May [d]			490	19,348	3.000	2.23
August [e]			1,219	65,282	7.433	7.46
September	3,945	73	400	23,802	2.439	2.72
October	420	50	111	6,825	.677	.78
November [f]			55	2,509	.335	.28

[a] 24 days.
[b] 23 days.
[c] 22 days.
[d] May 1-20. Does not include May flood, which washed gage away.
[e] 27 days.
[f] November 1-23.

MISCELLANEOUS MEASUREMENTS IN TENNESSEE RIVER DRAINAGE BASIN.

The following miscellaneous discharge measurements were made in the Tennessee drainage basin in 1902 by B. M. Hall and his assistants:

Date.	Stream.	Locality.	Discharge.
Mar. 11	Rock Creek	Lula Lake, near Flintstone, Ga., Walker County.	47
July 12	Coal Creek	Southern Rwy. bridge, Coal Creek, Tenn.	6
24	Clinch River	2 miles below Clinton, Tenn. (gage height 3.7 feet).	1,238

YAZOO RIVER DRAINAGE BASIN.

Yazoo River rises in the northwestern part of Mississippi. It flows south just west of the central portion of the State and enters the Mississippi River just above Vicksburg. The United States Geological Survey is maintaining a station on this river at Yazoo City under the direction of B. M. Hall.

YAZOO RIVER AT YAZOO CITY, MISS.

A gage has been maintained at this point by the Engineer Corps of the Army. It was replaced in 1901 by a new gage rod in three sections, marked with brass figures and brass tacks, the sections being placed as follows: The lowest, marked from −3 to +4.5 feet, is attached to the protecting work of the bridge; the middle section, marked from 4.5 to 18.5 feet, is attached to the piling that protects the bridge pier; the uppermost section, continuing the graduation up to 32.3 feet, is on a post under the approach to the bridge. The highest known water occurred in 1882, reaching a gage height of 36.5 feet; the lowest occurred on October 15 to 17 and 20 to 22, 1896, with a gage height of −2.8 feet. The danger line is at 25 feet. A bench mark was established on the top of the upstream cylinder of the second pier from the left bank, at a distance of 85 feet from the initial point for soundings, which is on the downstream end of iron bridge on the left bank. The elevation of the mark is 35.85 feet above the zero of the gage. Other important bench marks in Yazoo City are the following: P. B. M. 12, Yazoo City, is a copper bolt in stone under ground, surmounted by an iron pipe and cap, in the north corner of the county court-house yard. It is 44.1 feet above the zero of the gage and 116.2 feet above mean sea level. P. B. M. 13, Yazoo City, is a copper bolt in stone under ground, surmounted by an iron pipe and cap, in the north corner of the public school yard, near Washington and Main streets. It is 29.2 feet above the zero of the gage, and 101.3 feet above mean sea level. Discharge measurements are made by the United States Geological Survey from the city toll bridge, one-half mile northwest from the Illinois Central station. The observer is P. C. Battaille. Daily gage heights are furnished by the Weather Bureau.

The following discharge measurements were made during 1902:

July 12: Gage height, 3.40 feet; discharge, 2,887 second-feet.
July 14: Gage height, 4.40 feet; discharge, 3,672 second-feet.
September 24: Gage height, −1.0 foot; discharge, 2,108 second-feet.
September 25: Gage height, −1.0 foot; discharge, 2,048 second-feet.

Daily gage height, in feet, of Yazoo River at Yazoo City, Miss.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	11.40	11.30	16.70	23.90	25.30	2.30	0.10	3.20	−0.70	−1.00	−2.10	4.90
2	11.50	12.40	16.60	23.80	25.00	1.90	.20	3.00	− .80	− .90	−2.10	5.80
3	11.40	12.80	16.60	23.80	24.70	1.80	.20	3.00	− .50	− .80	−2.10	5.80
4	11.00	13.20	16.60	23.80	24.40	1.60	.00	3.20	− .50	.00	−2.10	5.90
5	10.90	13.40	16.90	23.80	24.10	1.50	.00	3.60	− .50	.60	−2.10	6.00
6	10.80	13.70	16.90	23.80	23.70	1.50	−.10	4.00	− .30	1.00	−2.10	6.30
7	10.50	13.90	16.80	25.10	23.30	1.70	−.20	4.40	.00	1.30	-2.10	6.50
8	10.30	14.10	16.80	25.10	22.90	2.00	.00	4.50	.20	1.50	−2.10	6.90
9	10.00	14.30	16.80	25.00	22.40	2.20	.70	4.70	.30	1.50	−2.10	7.00
10	9.70	14.60	16.70	25.00	21.80	2.40	1.50	4.70	.00	1.20	−2.10	7.20
11	9.30	14.90	16.70	25.10	20.90	2.50	2.40	4.70	− .20	.90	−2.10	7.30
12	8.90	15.20	16.90	25.30	20.10	2.40	3.40	4.70	− .50	.70	−2.10	7.40
13	8.40	15.50	17.40	25.50	19.20	2.10	4.00	4.60	− .70	.50	−2.10	7.40
14	7.90	15.80	17.30	25.60	18.00	1.80	4.50	4.60	−1.10	.50	−2.10	7.50
15	7.30	16.00	17.30	25.80	16.90	1.50	4.90	4.50	−1.20	.50	−2.10	7.50
16	6.50	16.30	17.90	26.00	15.50	1.20	5.00	4.50	−1.30	.20	−2.10	9.80
17	5.70	16.40	17.80	26.20	14.20	.90	5.00	4.40	−1.40	− .20	−2.10	9.80
18	4.90	16.40	17.70	26.30	13.00	.50	4.70	4.40	−1.50	− .50	-2.10	10.20
19	4.20	16.40	17.70	26.40	11.90	.40	4.40	4.30	−1.50	−1.00	−2.10	10.90
20	3.50	16.30	17.80	26.50	10.80	.30	4.00	4.20	−1.50	−1.20	−2.10	11.50
21	3.20	16.20	18.00	26.60	9.70	.00	3.90	4.00	−1.50	−1.30	−2.10	12.00
22	3.50	16.10	18.10	26.60	8.50	−.10	3.50	3.80	−1.50	−1.50	−2.10	12.70
23	3.00	16.00	18.10	26.50	7.70	−.20	3.40	3.30	−1.50	−1.60	−2.10	13.20
24	3.50	16.00	19.00	26.50	6.70	−.30	3.00	2.60	−1.10	−1.60	−2.10	13.80
25	4.00	16.20	19.00	26.50	5.80	−.40	3.00	1.90	- 1.10	−1.70	−1.10	14.30
26	4.70	16.10	18.90	26.40	5.00	−.40	2.90	1.30	−1.10	−1.70	.20	14.80
27	5.40	16.20	21.00	26.20	4.40	−.40	2.90	.50	−1.00	−1.70	.80	15.20
28	6.40	16.60	24.80	26.00	3.90	−.40	2.90	−.10	−1.00	−1.80	1.50	15.40
29	7.40	.....	24.80	25.80	3.30	−.20	2.80	−.10	−1.00	−2.00	3.00	15.80
30	9.40	.....	24.30	25.60	3.00	.00	2.70	−.30	−1.00	−2.10	4.40	16.00
31	10.30	.....	24.00	.....	2.50	.....	2.60	−.60	.....	−2.10	.....	16.20

Rating table for Yazoo River at Yazoo City, Miss., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−2.0	1,830	1.0	2,620	4.0	3,870	11.5	10,500
−1.8	1,870	1.2	2,690	4.5	4,145	12.0	11,000
−1.6	1,915	1.4	2,760	5.0	4,440	12.5	11,500
−1.4	1,965	1.6	2,830	5.5	4,790	13.0	12,000
−1.2	2,015	1.8	2,900	6.0	5,150	13.5	12,500
−1.0	2,065	2.0	2,970	6.5	5,550	14.0	13,000
− .8	2,115	2.2	3,050	7.0	6,000	14.5	13,500
− .6	2,165	2.4	3,130	7.5	6,500	15.0	14,000
− .4	2,215	2.6	3,210	8.0	7,000	15.5	14,500
− .2	2,265	2.8	3,300	8.5	7,500	16.0	15,000
.0	2,320	3.0	3,390	9.0	8,000	16.5	15,500
.2	2,380	3.2	3,480	9.5	8,500	17.0	16,000
.4	2,440	3.4	3,570	10.0	9,000	17.5	16,500
.6	2,500	3.6	3,660	10.5	9,500	18.0	17,000
.8	2,560	3.8	3,760	11.0	10,000		

Estimated monthly discharge of Yazoo River at Yazoo City, Miss.

[Drainage area, 8,580 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
January	17,300	10,800	14,829	1.73	1.99
February	17,200	15,200	16,443	1.92	2.00
March	15,600	10,800	13,377	1.56	1.80
April	15,600	11,800	14,043	1.64	1.83
May	15,600	8,200	13,094	1.53	1.76
June	8,000	2,350	4,478	.52	.58
July	2,440	1,965	2,181	.25	.29
August	8,100	1,965	3,805	.44	.51
September	8,100	2,620	5,456	.64	.71
October	6,400	1,965	3,327	.39	.45
November	2,500	1,870	2,046	.24	.27
December	10,600	2,115	5,978	.70	.81
The year	17,300	1,965	8,255	.96	13.00
1902.					
January	10,500	3,390	8,493	0.99	1.14
February	15,600	10,300	14,082	1.64	1.71
March	23,800	15,600	17,448	2.03	2.34
April	25,600	22,800	24,477	2.85	3.18
May	24,300	3,170	14,004	1.63	1.88
June	3,170	2,215	2,651	.31	.35
July	4,440	2,265	3,281	.38	.44
August	4,260	2,165	3,578	.42	.48
September	2,410	1,940	2,104	.25	.28
October	2,795	1,810	2,223	.26	.30
November	4,090	1,810	2,023	.24	.27
December	15,200	4,380	9,065	1.06	1.22
The year	25,600	1,810	8,619	1.00	13.59

GREAT LAKES DRAINAGE BASIN.

Owing to the irregularity in the general outline of the Great Lakes, the drainage areas in this section have not been arranged in regular geographical order. The general plan of arrangement is from east to west, although the report is properly divided by States, viz, Ohio, Michigan, and Wisconsin.

MAUMEE RIVER DRAINAGE BASIN.

Maumee River is formed by the junction of St. Joseph and St. Marys rivers near Fort Wayne, Ind., and flows in a northeasterly direction through Ohio, emptying into Lake Erie at Toledo. The southern part of the basin is flat, the northern part gently rolling and hilly in places. Formerly the hilly section was covered with timber; but all the best has been cut, leaving a section of scrub timber, with occassional farms cleared and cultivated. At the station the bed of the stream is rocky and the current sluggish, the fall being only 1.1 feet per mile on an average. Two dams have been built on the Maumee—one at Defiance, to supply water for the Ohio State canals, and one at Grand Rapids, for furnishing water power. Blanchard and Ottawa rivers unite a short distance below Ottawa and form Auglaize River, which empties into the Maumee at Defiance, Ohio. The following gaging stations were maintained in this drainage basin during 1902 by the United States Geological Survey, under the direction of Benjamin H. Flynn; on the Maumee River at Waterville; on Blanchard River at Ottawa; on Ottawa River at Lima.

The data collected at these stations during 1902 are given on the following pages.

MAUMEE RIVER AT WATERVILLE, OHIO.

A station was established on this river by H. A. Pressey and B. H. Flynn, November 19, 1898. It is located at the highway bridge near Waterville, the gagings being made on the downstream side of the bridge. Zero of gage is on the left bank, marked by a nail in the guard rail. The wire gage is referred to a bench mark cut in the upstream side of the abutment on the left bank of the river. The elevation is 25.2 feet above gage datum. This is the lowest place on the river at which gagings can be made without being affected by backwater from the lake. The observer is J. E. Harper, station agent at Waterville, Ohio. No measurements were made at this station during 1902, and gage heights were taken only for a part of January.

BLANCHARD RIVER AT OTTAWA, OHIO.

This station was established November 22, 1902, by Benjamin H. Flynn. It is located at the Cincinnati, Hamilton and Dayton Railroad bridge in the town of Ottawa, Ohio. The upper portion of the gage is inclined and graduated, so as to read directly to feet and tenths. The lower portion of the gage is vertical and graduated to feet and tenths. It is spiked to a stake driven into the ground. The initial point of sounding is on the right bank of the river. The river is straight for 200 feet above and 500 feet below the station. The right bank is high and does not overflow. The left bank is low but seldom overflows, as the water is confined by the railroad. The bed of the stream is firm gravel, with mud along the banks. The current is sluggish. The bench mark is the upper of two parallel marks cut in the east end of the south main pier of the bridge; elevation, 14.0 feet above the zero of the gage. The observer is C. W. Ewing, who reads the gage twice daily.

The following discharge measurements were made during 1902:

November 22: Gage height, 2.65 feet; discharge, 332 second-feet.
December 23: Gage height, 9.80 feet; discharge, 1,845 second-feet.

Daily gage height, in feet, of Blanchard River at Ottawa, Ohio.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		2.93	12		3.12	23	1.20	9.72
2		2.88	13		4.90	24	.85	7.68
3		4.85	14		4.70	25	.78	5.25
4		7.68	15		4.38	26	.45	3.10
5		7.60	16		7.85	27	.42	2.38
6		5.90	17		11.82	28	.45	2.60
7		3.25	18		9.72	29	.55	2.60
8		2.65	19		7.50	30	2.10	2.50
9		2.80	20		6.05	31		2.50
10		2.80	21		8.65			
11		2.80	22	2.65	10.60			

OTTAWA RIVER NEAR LIMA, OHIO.

This station was established November 21, 1902, by Benjamin H. Flynn. It is located on the highway bridge, 2½ miles east of Lima, Ohio. The gage is a plain staff graduated to feet and tenths. It is spiked to the face of the abutment, and is read daily by Edward King. Discharge measurements are made by wading. The channel is straight for about 250 feet above and 500 feet below the station. The banks are both high, and overflow only in times of extreme floods. The bed of the stream is rocky. The bench mark is a cut in the downstream face of the left abutment; elevation, 8.0 feet above the zero of the gage.

During 1902 the following discharge measurements were made:

November 21: Gage height, 2.65 feet; discharge, 56 second-feet.
December 22: Gage height, 3.60 feet; discharge, 320 second-feet.

Daily gage height, in feet, of Ottawa River at Lima, Ohio.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		2.65	12		2.90	23	2.50	3.45
2		2.55	13		3.00	24	2.45	3.50
3		3.60	14		2.90	25	2.40	3.30
4		3.40	15		3.50	26	2.35	3.15
5		3.05	16		4.60	27	2.35	2.95
6		2.75	17		4.10	28	2.30	2.85
7		2.70	18		3.80	29	2.35	2.75
8		2.60	19		3.30	30	2.60	2.75
9		2.55	20		3.00	31		2.75
10		2.55	21	2.65	3.00			
11		2.70	22	2.60	3.60			

HYDROGRAPHIC FEATURES OF MICHIGAN.

With the exception of a small area in the region of the Lac Vieux Desert, on the Wisconsin-Michigan boundary, the entire drainage of the State of Michigan is tributary to the Great Lakes system. The State contains slightly over one-third of the aggregate drainage tributary to the Lakes north of Lake Erie. The climate of both peninsulas, surrounded as they are by these great water bodies, is undoubtedly tempered and modified by the influence of the Great Lakes, which produces certain insular characteristics.

Land and water surface of Michigan in the several Great Lake basins, in square miles.[a]

Lake.	Total land drained.	Land in Michigan.	Total water area.	Water in Michigan.
Superior	48,600	7,860	31,800	16,653
Michigan	45,700	28,500	22,400	12,922
Huron	52,100	16,700	23,200	9,925
St. Clair	6,320	2,160	495	460
Erie	24,480	2,290	10,000	

[a] U. S. Deep Waterways Commission, 1896, and U. S. Land Survey, 1900.

The streams of the State are of commercial importance for purposes of agriculture, public water supply, water power, lumbering, and navigation. The natural drainage has been, however, generally unfavorable to agriculture, the enormous natural marsh and swamp areas rendering much of the best land unfit for cultivation in its natural state. Out of the total of 57,530 square miles of land surface there

were, in 1901, 15,422 square miles of improved farm lands; that is, an average throughout the State of 26 per cent of the total area was under cultivation. In the southern four tiers of counties of the Lower Peninsula the percentage of the total area now tillable is very much greater, the ratio gradually decreasing to the north of Saginaw Bay and becoming almost nil for a large portion of the Upper Peninsula. In the southern four tiers of counties a large portion of the land now under cultivation lies in basins which have been artificially drained. This drainage comprises: (1) The cutting of artificial channels to draw off the surplus ground waters into the streams; (2) dredging, cleaning, and removing beaver dams and other obstructions from natural stream tributaries and water courses, thereby lowering their water level and with this the water horizon in the adjoining land.

The flat topography, the original forest-covered condition, and the sluggish character of the streams have all been conducive to the silting up of channels and their obstruction by logs and drift, and they have also rendered easy the flooding of large tracts and the formation of beaver meadows before settlement began. Hundreds of miles of drainage channels have been cut or cleared in many of the southern counties within the past fifty years. The result has been an extremely important change in the hydrography of the State. The effect of thus drawing off more rapidly the surface waters and surplus ground water has undoubtedly been to increase the maximum and to decrease the minimum flow. Whether or not a gradual decrease in the total annual yield of the streams has taken place can not be stated. It is possible that the total run-off of many basins has actually increased, because of the smaller water surface exposed to evaporation and the greater facility with which the water reaches the streams. The value of the streams for water power has probably been greatly diminished.

The settlers of this region were largely from the Eastern States. Comparing these streams with those of the northeastern Appalachian region, it is observed that they are relatively constant in flow, in spite of the detrimental influence of drainage. The streams are comparatively few and yield small annual run-off, on account of the relatively low rainfall and the high evaporation induced by the flat, sandy soil and the cultural conditions. Storage reservoirs in the Lower Peninsula are, with few exceptions, unfeasible.

The interests of agriculture and navigation have always been considered paramount to those of water power. No mill acts have been passed and no legislative efforts have been made to encourage the utilization of the power of the streams[a]. Inland rivers are to-day of little importance to navigation. A lock system on St. Joseph River was abandoned many years ago. Saginaw, Kalamazoo, Muskegon,

[a] A law passed in 1887 granting to waterpower companies the power of eminent domain, enabling them to condemn land for flowage, has been declared unconstitutional by the Supreme Court.

Manistee, and Thunder Bay rivers, Grand River below Grand Rapids, and other rivers are utilized as harbors and for navigation near their outlets. Cheboygan River and a system of lakes, extending nearly across the northwestern Lower Peninsula from Cheboygan to Petoskey, form a navigation route still extensively utilized, about 20.000 passengers being carried during the summer season each year.

Probably the most important use made of the streams has been in connection with lumbering operations. The following table shows the extent of log rafting on a few of the more important rivers:

Amount of timber floated on Michigan streams.

Stream.	Average number of feet of logs now scaled per year.[a]
Manistee River	75,000,000
Cheboygan River	35,000,000
Menominee River	250,000,000
Escanaba River	55,000,000
Au Sable River	[b]55,000,000
Manistique River	60,000,000

[a] Amount ten to twenty years ago much greater. Amount now rapidly decreasing in most cases.
[b] Includes logs brought by rail.

For purposes of water supply the streams are of less importance than in many States. Their fall is, as a rule, so slight that gravity supplies can not be obtained. Owing to the superficial topography of the Pleistocene deposits, the great depth of drift, and the topography of the rock horizons underneath, excellent and abundant artesian water can be obtained in most sections of the State, and especially in the lake coast region, where the larger towns are located. The Great Lakes themselves also afford water of suitable quality for public use when required.

Public water supply systems in Michigan.[a]

Source.	Number.	System.	Number.
Artesian and shallow wells	80	Pumping	155
Streams, rivers	42	Gravity	4
Great Lakes	31	Total	159
Springs	6		

[a] Manual of American Waterworks, M. N. Baker, 1897.

In behalf of navigation a statute has been enacted and embodied in the State highway laws requiring a franchise to be obtained from the

county board of supervisors before the erection of a dam can be undertaken on any public stream. Inquiries have been received from those interested in water-power projects as to the proper method of procedure. A copy of the law is given below:

LAW OF DAM CONSTRUCTION ON MICHIGAN STREAMS.[a]

§ 2495. SEC. 22. Whenever any person or persons or any incorporation shall wish to construct a dam across any such stream as is mentioned in the preceding section, such person or persons or incorporation shall present to the board of supervisors, or file with their clerk, to be presented to them at their next meeting, a petition praying for leave to construct such dam, and setting forth the purpose, location, height, and description of such dam, and whether it is proposed to construct a lock or chute or apron, and of what description, for the passage of boats, vessels, rafts, or timber; and before the same shall be heard and determined by such board it shall be made to appear to the board that notice of such application, signed by the petitioners, and stating substantially the contents of such petition, has been published in some newspaper printed in each county through which such streams run, if there be a newspaper published in such county, and also in one newspaper, at least three weeks previous to the hearing of such application, published in the city of Detroit; and on such hearing any person or persons shall be heard in favor of and in opposition to the prayer of the petition; and such board may adjourn such hearing to any other time or place, and they may grant or refuse the prayer of such petition. And the determination shall be entered at length upon the record of said board. And if such board shall allow the said dam to be constructed, the petitioner shall be at liberty to construct the same by complying fully with the terms and conditions set forth in their petition; and after having obtained such right and constructed such dam, such petitioners, their heirs, successors, or assigns, may, if such dam be destroyed or decayed, construct a new dam, subject to all the same terms and conditions, on the same site, without again applying to such board: *Provided*, That nothing in this act contained shall be construed as giving to such board of supervisors any power to grant the right to any person or persons or corporation to flow or in any manner to take or injure the lands of any person or persons by or in consequence of constructing such dam.

The petition under this section must set forth in detail the whole plan of the proposed dam and the capacity and character of any chute or passage to be constructed therein; so that by means of the notice all persons interested may be informed, in advance of the hearing, of the precise nature of the project, and be enabled to judge of the nature and extent of the obstruction. Nor can the resolution of the board supply details and facts required to be set forth in the petition as a basis for their power to act. (Powers *v.* Irish, 23 Mich., 429.)

[a] From Laws and Supreme Court Decisions Relating to Highways and Bridges, published by secretary of state of Michigan, 1900, p. 157.

WATER POWER IN USE IN MICHIGAN, 1900.

The water power has been most extensively used for flour milling and lumbering purposes. The total horsepower of water wheels installed, as reported by the United States Census of 1900, is given below:

Water power in use in Michigan, 1900.

Industry.	Horse-power.	Industry	Horse-power.
Brick and tile	20	Paper	11,627
Hosiery and knit goods	257	Silk and silk goods	200
Chemicals	1,000	Agricultural implements	152
Explosives	150	Shipbuilding	65
Lumber and sawmill and lumber products	6,746	Iron and steel	150
		Printing and publishing	52
Flour and grist mills	19,866		
Carriages and wagons	60	Total	40,345

Lake Superior affords a most valuable water power resource at Sault Ste. Marie.

HYDROGRAPHIC FEATURES OF THE UPPER PENINSULA.

The hydrography of the Upper Peninsula differs from that of the Lower Peninsula in the greater extent of forest and untilled lands, the absence of artificial drainage, the precipitous watersheds with a large per cent of rock outcrop, and the rapid fall of the streams. Little water power has been developed. Since the advent of successful electric transmission, attention has been devoted to the utilization of the natural power resources for general mining purposes and for air compression for mine supply. Use has been made of many streams to supply the launders of copper stamp mills. One of these mills often requires as much water for ore washing and transport as would be needed for the municipal supply of a large city.

DEAD RIVER DRAINAGE BASIN.

Dead River lies in Marquette County, Upper Peninsula, Michigan, and flows into Lake Superior. The drainage basin is rugged, precipitous, and for the most part timber covered. The soil is sandy and is underlain with rock, which forms the bed of the stream throughout its lower course. The only storage reservoir of importance is Silver Lake, with an area of 1,600 acres, and capable of draft to a depth of 10 feet. This and one other lumbermans' dam on the stream are controlled by the South Arm Lumber Company. The lower basin is narrow. The greater portion of the drainage area lies above The Hoist,

about 14 miles from the mouth of the river. The fall in the lower reaches of the stream is very rapid. The aggregate descent is stated to be 850 feet in a distance of 10 miles. The most notable pitches, beginning at the mouth of the stream, are as follows:

Lake Superior Powder Company, near Marquette, about 20 feet fall.

The Valley Flour Mill, 18 feet fall, 4 miles from mouth.

Marquette electric-light plant utilizes 85 feet fall, but has a total fall of 112 feet, 6 feet fall above the present dam and 18 feet below the tailrace remaining undeveloped; rated capacity of turbines, 1,000 horsepower. The electric current generated is transmitted to Marquette, a city of 10,000 population, situated on the shore of Lake Superior, 6 miles distant.

From 2 to 5 miles above Forestville are rapids aggregating two available falls of 100 feet each, owned by J. M. Longyear, of Marquette.

At The Hoist, about 8 miles north from Negaunee and Ishpeming, is a fall of 110 feet, owned by the Oliver Iron Mining Company.

The drainage area has been estimated from a map of the Cleveland-Cliffs Iron Company, as follows:

Drainage areas, Dead River.

Location.	Square miles.	Increment.
Above The Hoist	126.3	.....
Above Forestville	141.9	15.6
Above mouth	165.5	23.6

The mean annual precipitation in the vicinity of Marquette is stated to be 32 inches.

Dead River is not a large stream, but owing to its great fall, its well-sustained flow, and its location near important mining centers, it attains unusual economic importance.

DEAD RIVER AT THE HOIST, NEAR NEGAUNEE, MICH.

July 10, 1902, a gaging record was started at The Hoist under the direction of Frank Drake, chief engineer of the Oliver Iron Mining Company, Duluth, Minn. A suitable cross section was selected and a cableway of 91 feet span was erected across the stream about 700 feet south of the lumbermen's dam. The gaging station is located in the northeast portion of T. 48 N., R. 27 W. The stage of the stream is observed daily and current-meter discharge measurements are made from time to time. The hydrographic work has been done by C. G. Mason, E. M., acting in cooperation with the United States Geological Survey. The bed of the stream is rock and the velocity of the current relatively high. These features, together with the location just below a dam, tend to keep the gaging section open during winter.

Discharge measurements of Dead River at The Hoist, near Negaunee, Mich.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
July 11	C. G. Mason	10.70	140
July 20	do	10.60	105
September 26	do	10.60	105
October 2	do	10.55	88
October 6	do	10.50	86
October 31	Savicki and Mason	10.80	176
November 20	C. G. Mason	11.05	234

Daily gage height, in feet, of Dead River at The Hoist, near Negaunee, Mich.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						
1	.....	10.60	10.70	10.55	10.80	10.60
2	.....	10.60	10.70	10.55	10.85	10.55
3	.....	10.60	10.75	10.55	10.95	10.90
4	.....	10.60	10.80	10.55	10.80	10.80
5	.....	10.65	10.75	10.50	10.80	10.75
6	.....	10.65	10.75	10.50	10.75	10.80
7	.....	10.60	10.70	10.50	10.70	10.85
8	.....	10.55	10.70	10.55	10.65	10.70
9	.....	10.60	10.70	10.55	10.70	10.65
10	10.75	10.55	10.65	10.55	10.65	10.60
11	10.70	10.55	10.65	10.55	10.65	10.60
12	10.65	10.55	10.65	10.60	11.20	10.55
13	10.65	10.55	10.65	10.65	11.25	10.55
14	10.60	10.55	10.60	10.70	11.55	10.50
15	10.60	10.55	10.60	10.80	11.05	10.50
16	10.60	10.55	10.60	10.70	10.80	10.55
17	10.65	10.60	10.65	10.55	11.05	10.55
18	10.60	10.60	10.65	10.60	10.85	10.50
19	10.55	10.75	10.60	10.55	10.85	10.50
20	10.60	10.75	10.60	10.55	11.05	10.50
21	10.60	10.70	10.65	10.60	10.70	10.45
22	10.60	10.70	10.65	10.75	10.70	10.45
23	10.60	10.65	10.70	10.85	10.75	10.50
24	10.65	10.65	10.60	11.40	10.70	10.80
25	10.65	10.65	10.60	11.45	10.65	10.90
26	10.75	10.60	10.60	11.40	10.60	10.70
27	10.70	10.60	10.60	11.10	10.60	10.65
28	10.65	10.60	10.55	11.05	10.60	10.50
29	10.60	10.65	10.55	10.90	10.55	10.50
30	10.60	10.65	10.55	10.80	10.60	10.45
31	10.60	10.75	.....	10.80	.....	10.45

CARP RIVER DRAINAGE BASIN.

Carp River, situated in Marquette County, Upper Peninsula, Michigan, drains a diversified area of sand and rock, mostly wooded, and with little cultivated land. The percentage of swamp area is probably

less than for most streams of this locality. There are, however, a number of lakes in the region of the headwaters, aggregating perhaps 3 square miles of water surface. From Teal Lake is pumped the water supply of Negaunee, the stated average consumption being 1.25 second-feet per day. From Lake Sally is drawn by gravity the supply of Ishpeming, the average daily consumption being stated at 1.4 second-feet.

The stream enters Lake Superior at Carp River furnace, 1 mile south of Marquette. A series of rapids occurs in the stream a short distance above its mouth, where a large fall can be developed.

CARP RIVER NEAR MARQUETTE, MICH.

A weir was erected 500 feet above the mouth of the stream by the Cleveland-Cliffs Iron Company, and the daily gage record was started July 5, 1902. The gage readings have been furnished by Noah Gray, superintendent of the furnace. The weir has a level crest 10.04 feet in length, with two end contractions. The water flows over a sharp edge or crest lip, but falls on a nearly horizontal apron at a slightly lower level on the downstream side. In order to calculate the discharge of the nappe as modified by the apron, the weir formula of Bazin, using coefficients from experiment series No. 142, has been used. During high stages of the stream, the water also flows over the flashboards forming the wings of the weir. The gage is attached vertically to a framework 16 feet upstream, and the same distance to the left of the weir crest.

The following discharge measurements were made at the highway bridge at the mouth of the stream:

Discharge measurements of Carp River near Marquette, Mich.

Date.	Gage height.	Discharge by current meter.	Calculated discharge over weir.
1902.	*Feet.*	*Second-feet.*	*Second-feet.*
September 8	1.59	68.0	68.1
October 30	1.71	78.9	75.7

The gage datum is referred to the east rail of the Duluth, South Shore and Atlantic Railroad at the tramroad crossing.

	Feet.
Elevation of bench mark	100.00
Crest of weir	96.28
Zero of gage	96.28

The drainage area above Eagle Mills is 60 square miles; above the mouth, at Marquette, it is 86 square miles.

Mean daily discharge, in second-feet, of Carp River at Marquette, Mich.

[Drainage area, 86 square miles.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						
1	.....	47	52	38	61	56
2	.....	47	50	38	61	54
3	.....	42	50	39	61	52
4	.....	40	52	39	61	52
5	.....	38	56	38	59	50
6	132	39	66	38	56	47
7	160	39	71	39	52	47
8	173	38	61	38	52	45
9	173	38	60	36	47	44
10	160	37	56	35	52	42
11	107	36	52	34	71	42
12	80	34	47	34	104	41
13	59	34	42	44	218	41
14	54	34	40	54	178	41
15	52	34	40	47	169	41
16	50	34	40	47	178	41
17	47	34	38	52	178	40
18	47	34	38	53	173	40
19	42	51	38	54	173	40
20	42	47	38	50	169	38
21	40	47	38	51	151	(a)
22	39	45	38	50	143	.....
23	38	42	39	52	135	.....
24	47	40	38	79	110	.....
25	82	38	38	82	87	.....
26	80	34	38	79	77	.....
27	69	34	38	78	71	.....
28	61	32	37	77	71	.....
29	54	30	37	75	66	.....
30	54	32	37	69	61	.....
31	49	47	.....	.....	.....	.....
Mean	76	39	45	51	105	45

a No record December 21 to 31.

Estimated monthly discharge of Carp River at Marquette, Mich.

[Drainage area, 86 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
July	173	38	76	0.89	1.03
August	51	30	39	.46	.53
September	71	37	45	.53	.59
October	82	34	51	.60	.69
November	218	47	105	1.23	1.37
December	56	38	45	.53	.61

MENOMINEE RIVER DRAINAGE BASIN.

Menominee River forms the dividing line between Wisconsin and the Upper Peninsula of Michigan. It is formed by the junction of Brule River and Michigamme River in T. 41 N., R. 30 W. It flows thence in a general southeasterly direction, entering Lake Michigan in Green Bay at Marinette. Its total drainage area is approximately 4,000 square miles, of which 1,450 square miles lie in Wisconsin and 2,250 square miles in Michigan.

The headwaters of Brule River are in a region in northern Wisconsin interspersed with almost innumerable small lakes; but few of these are tributary to the Menominee River. The larger portion of the drainage comes from an elevated plateau, extending from the headwaters of Michigamme River, at an elevation of about 1,750 feet and at a distance of 12 miles from Keweenaw Bay, Lake Superior. This upland slopes gradually to the southeast. The river is, however, frequently interrupted in its southeasterly course by encountering barriers of rock strata, along which it flows, either to the north or to the south, until an outlet is reached. In its upper reaches the river flows over metamorphic base rock of granite, gneiss, and schist. Below the mouth of Pike River it crosses Potsdam sandstone for about 10 miles and thence flows across magnesian and Trenton limestone for about 28 miles to its mouth.

The main tributaries, beginning at the head, are Bois Brule or Burnt Woods River, called by the Indians the Wisacode, which in turn receives the Iron and the Paint or Mequacumecum River. Iron River is elsewhere described in connection with gagings of that stream. Paint River is formed by the junction of Net and Hemlock rivers at an elevation of 1,400 feet, and has a fall of about 7 feet per mile in its lower course. The basin of this stream, like that of the adjoining Michigamme River, contains a large percentage of swamp area. The topography is rough, though not mountainous. There are numerous small lakes and undrained hollows. Water power is developed at Crystal Falls for municipal lighting purposes, a fall of 18 feet being utilized to drive turbines of 350-horsepower capacity.

Michigamme River, the next large tributary from the Michigan side, has a total fall of about 500 feet. The region about its headwaters contains numerous lake areas. The largest of these is Lake Michigamme, which receives drainage from a tributary area of 140 square miles, and has a water surface of 6.5 square miles. In sec. 9, T. 41 N., R. 31 W., occurs a precipitous fall. Other tributaries from the north are Sturgeon and Little Cedar rivers. The main tributaries from Wisconsin are Pine, Pemebonwon, Pike, and Wausaukee rivers. The drainage basin is largely timber covered. Pine and spruce predominate, though hard woods are also found. The average annual precipitation over the drainage area is stated to be 35 inches. Owing

to the rapid fall of the streams, sites for extensive storage reservoirs are rare. The river makes a total descent, from its nominal head at the junction of Brule and Michigamme rivers to its mouth, of about 700 feet. This fall is chiefly concentrated in numerous rapids, usually in pairs, the more important of which are described below. The fall which could be obtained by the construction of dams will usually be greater than the natural descent, as stated. In some cases, a considerable length of rapids could thus be concentrated into a single head. Between the nominal head of the river and the entrance of Pine River, a distance of 14 miles, the drainage area increases from 1,796 to 1,833 square miles. In this region occur the Bad Water Rapids, Twin Falls, and Pine River Falls. Bad Water Rapids, 7 miles below the head of the river, give a direct descent of 5 feet over a granite or schist ledge, the stream being 100 feet wide. This fall is situated 3 miles upstream from the Chicago and Northwestern Railroad. Twin Falls, 3 to 4 miles farther downstream, consist of two drops of 12 feet each, located in sec. 12, T. 40 N., R. 31 W., Michigan, near the Chicago and Northwestern Railroad, at an elevation of 1,100 feet above tide. Pine River Falls comprise a series of rapids, both above and below the mouth of Pine River, of possibly 20 feet total fall.

In the stretch of 18 miles from a point just below Pine River to the influx of Sturgeon River, the drainage area increases from 2,419 to 2,538 square miles. The total fall is about 225 feet. This section includes Upper or Big Quinnesec Falls, Lower or Little Quinnesec Falls, and Sand Portage Rapids. Both Upper and Lower Quinnesec Falls are developed. The Upper or Big Quinnesec Falls, with a head of 40 feet, affords power to compress air for the supply of mines at Iron Mountain, 2 miles distant. The river at the falls is 1,000 feet above tide, and passes over a greenstone ledge in a very narrow gorge, broadening out below and forming a stretch of slack water, with a fall of but 1.25 feet in 4 miles to Little Quinnesec Falls. Big Quinnesec Falls are in sec. 6, T. 38 N., R. 20 E., Wisconsin.

Little Quinnesec Falls, situated in sec. 15, T. 39 N., R. 30 W., Michigan, formerly partially developed under 25 feet head for wood pulp grinding, were redeveloped in 1898 by the Kimberly & Clark Company, for wood pulp and paper manufacturing. A head of 64 feet is obtained, and turbines of 5,800 horsepower have been installed.

Sand Portage Rapids afford a total fall of 30 to 40 feet, extending over sand shoals of 6 miles, but mainly concentrated in a narrow section in T. 39 N., R. 30 W., Michigan.

From below the mouth of Sturgeon River to a point just below Pemebonwon River, a distance of 10 miles, the drainage area increases from 2,934 square miles to 2,993 square miles. In this stretch occur Sturgeon Falls, one-half mile below the mouth of Sturgeon River, in sec. 22, T. 38 N., R. 21 E., Wisconsin. They have high rock ledge banks, with two pitches aggregating perhaps 12 feet fall.

From below Pemebonwon River to a point just below Pike River, a distance of 18 miles, the drainage area increases from 3,156 square miles to 3,279 square miles. The Pemena, Chalk Hill, and White rapids occur in this region. Pemena Falls, in sec. 21, T. 37 N., R. 28 E., Wisconsin, about one-half mile below Pemebonwon, are stated to afford a total fall of 60 feet in a distance of 2 miles, with one precipitous descent of 10 feet over metamorphic slaty schist. Eight miles farther downstream are Chalk Hill Rapids, stated to afford 8 feet fall in one-fourth mile, over slate rock. Four miles above Pike River occur White Rapids, affording a descent of about 20 feet in 3 miles, over gravel and bowlders.

From below the inflow of Pike River to a point just below Little Cedar River, a distance of 22 miles, the drainage increases from 3,566 to 3,792 square miles. Opposite the mouth of Little Cedar River Grand Rapids are formed by a descent over a hard Trenton limestone, underlain by softer strata. They have a total fall stated at 25 feet in a length of 3 miles.

From below Little Cedar River to the mouth of the stream, 22 miles, the drainage increases from 3,941 to 4,113 square miles. This section contains Twin Island Rapids, 16 miles above the mouth of the river, stated to afford 10 feet fall in three-fourths mile, formerly utilized by a sawmill. In crossing the Trenton limestone between Twin Islands and the mouth the river forms a series of rapids. The uppermost, Chappees Rift, has an undeveloped fall of about 10 feet. Of the remaining fall in the stream, 19 feet are taken up by three dams of the M. and M. Paper Company and the Menominee River Boom Company, the uppermost situated 1 mile above Marinette. The three have heads available, beginning at the uppermost, of 7, 5, and 7 feet, respectively. The power is utilized for lumber and paper manufacture.[a]

The following table gives the drainage area of Menominee River at various points. The drainage areas of Brule, Paint, Michigamme, and Sturgeon rivers are given separately. The figures from James L. Greenleaf's report, cited above, have been used in part.

Menominee River drainage areas.

	Square miles.	Increment.
BRULE RIVER.		
Brule River above Iron River	170	.....
Iron River above mouth	94.7	.....
Brule River, including Iron River	264.7	.....
Brule River above Paint River	305	40.3

[a] The above description of Menominee River Rapids is largely from data furnished by G. W. Hanley, of the Menominee River Boom Company, and from the report of James L. Greenleaf, C. E., on Water Power of the Northwest, Tenth United States Census, vol. 17, pp. 69-81.

Menominee River drainage areas—Continued.

	Square miles.	Increment.
PAINT RIVER.		
Net River above West Branch Paint River	234.4	.....
West Branch Paint River above Net River	287.9	.....
West Branch Paint River and Net River at junction	522.3	.....
Paint River, including Hemlock River	560.4	38.1
Paint River at Crystal Falls	678.5	118.1
Paint River at mouth	738.5	60
Brule River at junction with Michigamme River	1,044	.....
MICHIGAMME RIVER.		
Michigamme River above outlet of Lake Michigamme	234.1	.....
Michigamme River above Mitchikan River	374.7	140.6
Mitchikan River	179.1	.....
Michigamme River, including Mitchikan River	553.8	.....
Michigamme River above junction with West Branch	559.7	5.9
West Branch Michigamme River	80.3	.....
Michigamme River, including West Branch	640	.....
Michigamme River at Mansfield mine	664.7	24.7
Michigamme River at mouth	723.7	59
MENOMINEE RIVER.		
Menominee River at junction of Brule and Michigamme rivers	1,769	.....
Menominee River above junction with Pine River	1,833	.....
Pine River	586	.....
Menominee River, including Pine River	2,419	.....
Menominee River above Sturgeon River	2,538	.....
Sturgeon River, East Branch	117	.....
Sturgeon River, West Branch	89	.....
Sturgeon River at junction of both branches	206	.....
Sturgeon River at mouth	396	190
Menominee, including Sturgeon River	2,934	.....
Menominee above junction with Pemebonwon River	2,993	59
Pemebonwon River, Wisconsin	163	.....
Menominee, including Pemebonwon River	3,156	.....
Menominee River above Pike River	3,274	118
Pike River, Wisconsin	292	.....
Menominee River, including Pike River	3,566	.....
Menominee River above Little Cedar River	3,792	226
Little Cedar River	149	.....
Menominee River, including Little Cedar River	3,941	.....
Menominee River at mouth	4,113	172

In addition to its value for water power, air compressing, and water supply to the adjacent mines, Menominee River is of great importance as a lumbering stream. Numerous dams have been constructed, usually of spar or timber-crib design, for flooding logs, thus taking up the fall of many of the rapids described above. A list of the dams in Menominee Basin is given below:

Lumbermen's dams on Menominee River and its branches

Description.	River.	State.	Section.	Township.[a]	Range.
Dam No. 1	Menominee	Michigan	4	31	27
Dam No. 2	do	do	4	31	27
Dam No. 3	do	do	4	31	27
Pemene Falls	do	Wisconsin	21	37	28
Pemene Dam	do	do	24	37	21
Shakie Lake Dam	do	Michigan	24	35	29
Dam No. 1	Michigamme	do	7	43	31
Do	Brule	do	32	41	33
Dam No. 2	do	do	21	42	34
Dam No. 3	do	do	18	42	36
Dam No. 1	Paint	do	14	42	32
Dam No. 2	do	do	11	44	34
Dam No. 1	Pine	do	28	39	18
Dam No. 2	do	do	11	39	15
Dam No. 3	do	do	15	39	14
Dam No. 4	do	do	36	40	13
Dam No. 1	Pike	Wisconsin	8	35	21
Dam No. 2	do	do	16	35	20
Dam No. 1	North Branch of Pike River.	do	20	36	20
Dam No. 2	do	do	6	36	19
Do	South Branch of North Branch of Pike River.	do	29	37	18
Dam No. 1	South Branch of Pike River.	do	19	35	20
Dam No. 2	do	do	32	36	19
Dam No. 3	do	do	35	36	18
Dam No. 4	do	do	17	36	18

[a] Land-survey townships are numbered northerly from the principal parallel; and ranges in Michigan are numbered westerly and in Wisconsin easterly from the principal meridian of the respective States.

The first dam constructed on the stream was built for a gristmill in 1832. The lumbering interests soon outweighed the value of the water power, and little progress has been made in power development

until recently. The accompanying table, furnished by the Menominee River Boom Company, shows the total number of logs or feet of lumber rafted on Menominee River since the organization of the Menominee River Manufacturing Company in 1866.

Logs and lumber scaled on Menominee River from 1868 to 1901, inclusive.

Year.	Number of logs.	Feet B. M.	Year.	Number of logs.	Feet B. M.
1868		62,809,804	1886	2,141,293	387,489,272
1869		85,744,573	1887	2,517,445	462,280,890
1870		197,300,150	1888	2,681,218	513,703,492
1871		117,342,697	1889	4,245,763	642,137,318
1872		142,993,976	1890	2,904,436	433,876,844
1873		122,101,228	1891	3,276,591	430,590,085
1874		114,310,556	1892	4,416,767	560,938,627
1875		112,026,280	1893	4,168,187	490,896,814
1876		148,510,313	1894	3,360,746	345,675,068
1877		137,120,601	1895	3,616,275	374,643,625
1878	817,395	137,086,041	1896	3,101,463	337,987,807
1879	1,095,885	181,197,529	1897	2,259,119	232,677,937
1880	1,258,771	240,660,524	1898	3,262,216	291,229,121
1881	1,470,689	265,187,163	1899	3,090,699	268,234,278
1882	1,920,788	344,674,448	1900	3,156,027	249,351,247
1883	2,083,333	333,285,369	1901	3,066,167	247,130,515
1884	2,286,639	377,738,266	Total	64,196,217	9,724,539,384
1885	1,998,305	335,606,926			

MENOMINEE RIVER AT LOWER QUINNESEC FALLS, WISCONSIN.

The following tables, giving mean daily discharge and run-off of Menominee River at Lower Quinnesec Falls during a portion of the years 1898 and 1899, have been furnished by the Kimberly & Clark Company, of Niagara, Wis. The discharge was determined by Joseph H. Wallace, C. E., by means of float measurements at various stages, taken in a measuring course about one-fourth mile above Lower Quinnesec Falls. These measurements were made May 11 to June 15, 1898, and comparative observations of the stream stage were taken. Beginning May 23, 1898, a series of gage readings were taken each day at 7 a. m., 1 p. m., and 6 p. m., from which the daily discharge here given has been deduced. During the period in which the records were kept the flow of the stream was modified to some extent by the opening and closing of lumbermen's dams above.

Mean daily discharge, in second-feet, of Menominee River at Lower Quinnesec Falls, Wisconsin.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1898.								
1	.....	.....	3,253	2,740	794	.....	3,278	3,575
2	.....	.....	2,257	2,458	498	.....	2,080	.....
3	.....	.....	1,640	.....	2,797	.....	1,947	3,601
4	.....	.....	1,692	.....	1,122	.....	2,211	3,265
5	.....	.....	.....	2,321	753	2,633	3,251	3,502
6	.....	.....	2,269	1,611	1,184	797	.....	.....
7	.....	.....	3,176	1,926	.....	1,360	3,066	3,556
8	.....	.....	.....	.....	.....	2,282	3,341	3,382
9	.....	.....	3,235	1,491	.....	1,317	.....	.....
10	.....	.....	3,309	.....	.....	2,824	3,092	3,277
11	.....	.....	3,616	655	.....	.....	3,870	2,703
12	.....	.....	3,468	771	.....	3,263	3,913	2,289
13	.....	.....	.....	676	.....	3,099	2,931	.....
14	.....	.....	3,403	952	.....	2,791	2,977	1,528
15	.....	.....	2,674	1,097	2,263	2,697	3,060	1,523
16	.....	.....	2,471	.....	1,159	3,334	.....	1,484
17	.....	.....	2,555	.....	790	3,114	3,284	1,656
18	.....	.....	2,032	811	1,277	.....	.....	2,419
19	.....	.....	.....	877	949	3,544	.....	2,799
20	.....	.....	0	1,657	.....	3,349	3,381	.....
21	.....	.....	.....	1,522	.....	2,668	3,348	2,891
22	.....	.....	1,731	1,853	3,269	2,785	3,510	3,000
23	.....	.....	1,551	1,466	4,493	2,704	.....	3,253
24	.....	.....	1,696	.....	4,968	.....	3,543	2,843
25	.....	.....	1,447	2,044	4,660	.....	.....	.....
26	.....	3,802	.....	1,308	4,726	2,583	.....	.....
27	.....	2,887	1,955	420	3,097	2,626	3,278	.....
28	.....	2,443	.....	1,656	.....	2,296	3,160	.....
29	.....	.....	2,315	1,363	.....	2,108	3,201	.....
30	.....	2,755	2,263	.....	.....	2,290	.....	.....
31	.....	3,543	.....	.....	.....	.....	5,735	.....
Mean	.....	3,086	2,459	1,439	2,282	2,566	3,248	2,766
1899.								
1	.....	.....	3,421	2,120	1,420	.....	.....	.....
2	.....	.....	3,768	1,988	1,408	.....	.....	.....
3	.....	.....	3,517	1,790	1,413	.....	.....	.....
4	.....	.....	3,922	.....	1,789	.....	.....	.....
5	.....	.....	4,347	2,377	1,722	.....	.....	.....
6	.....	.....	4,266	2,083	1,686	.....	.....	.....
7	.....	.....	4,265	2,006	.....	.....	.....	.....
8	.....	.....	4,374	1,896	.....	.....	.....	.....
9	.....	.....	4,624	.....	.....	.....	.....	.....
10	.....	.....	4,127	.....	.....	.....	.....	.....
11	3,744	.....	3,974	2,198	.....	.....	.....	.....
12	3,470	.....	3,495	2,197	.....	.....	.....	.....
13	3,083	.....	3,420	1,989	.....	.....	.....	.....
14	3,982	.....	3,253	1,897	.....	.....	.....	.....
15	4,384	3,744	4,027	1,790	.....	.....	.....	.....
16	.....	4,256	4,159	2,083	.....	.....	.....	.....
17	.....	.....	3,160	2,341	.....	.....	.....	.....
18	.....	.....	3,543	804	.....	.....	.....	.....
19	4,642	.....	3,543	2,257	.....	.....	.....	.....

Mean daily discharge, in second-feet, of Menominee River at Lower Quinnesec Falls, Wisconsin—Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1899.								
20			4,027	2,521				
21			3,373	1,518				
22			2,541	1,487				
23			3,543	1,277				
24	4,321		3,494	1,433				
25	4,463	4,485	2,711	1,593				
26		4,349	2,438	1,593				
27		4,402	2,297	1,380				
28		4,027	2,521	1,534				
29		3,847	2,121	1,587				
30		3,920	2,017	1,645				
31		4,078		1,574				
Year	4,011	4,112	3,476	1,819	1,573			

Estimated monthly discharge of Menominee River at Lower Quinnesec Falls, Wis.

[Drainage area 2,432 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1898.					
May	3,802	2,443	3,086	1.26	1.45
June	3,616	1,447	2,459	1.01	1.13
July	2,740	655	1,439	.59	.68
August	4,968	498	2,282	.94	1.08
September	3,544	797	2,566	1.05	1.17
October	5,735	1,947	3,248	1.34	1.54
November	3,601	1,484	2,766	1.14	1.27
1899.					
April	4,642	3,083	4,011	1.65	1.84
May	4,485	3,744	4,112	1.69	1.95
June	4,624	2,017	3,476	1.43	1.60
July	2,521	804	1,819	.75	.86
August	1,789	1,408	1,573	.65	.75

MENOMINEE RIVER NEAR IRON MOUNTAIN, MICH.

A gaging station was established at the Homestead highway bridge, 2½ miles south of Iron Mountain, September 4, 1902. The gage is a vertical scale graduated to feet and tenths and attached to the

upstream side of the right-hand bridge abutment. The bridge has a single span of 220 feet. The bed is of earth, and the channel is straight for some distance both above and below the bridge. The gage is referred to the top of the 12-inch timber bridge seat on the right-hand abutment over the gage, the elevation of which is assumed to be 100 feet, the gage datum being elevation 77.32 feet. The gage readings are taken at 8 a. m. and 6 p. m. each day by Theodore Moll. The stream freezes across underneath the bridge, and special winter discharge measurements are required to determine the flow.

The drainage area above the gaging station is approximately 2,415 square miles.

During 1902 the following discharge measurements were made by R. E. Horton and W. V. Savicki:

September 4: Gage height, 1.90 feet; discharge, 1,322 second-feet.
November 4: Gage height, 2.67 feet; discharge, 1,584 second-feet.

A measurement of low-water discharge of Crystal Lake outlet, near Iron Mountain, September 4, 1902, showed a discharge of 2.25 second-feet or 0.45 second-foot per square mile from a flat sand area of 5 square miles,[a] containing 0.1 square mile lake surface.

Mean daily gage height, in feet, of Menominee River near Iron Mountain, Mich.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1	.....	1.67	2.52	1.60	17	1.40	1.65	6.45	2.55
2	.....	1.53	2.80	2.22	18	1.45	1.92	5.65	2.70
3	.....	1.55	2.95	2.80	19	1.35	1.60	5.35	2.63
4	1.90	1.45	2.72	2.25	20	1.35	1.65	5.00	2.75
5	1.60	1.55	2.85	1.85	21	1.20	1.57	4.47	2.75
6	2.00	1.58	2.95	1.95	22	1.45	1.65	4.45	2.57
7	2.25	1.60	2.50	2.25	23	1.52	1.67	3.90	2.40
8	2.35	1.67	2.60	2.70	24	1.48	2.42	3.92	2.32
9	2.05	1.77	2.50	3.45	25	1.47	2.80	3.45	2.35
10	1.92	1.30	2.40	3.35	26	1.40	3.22	3.30	2.20
11	1.87	1.50	2.45	3.60	27	1.40	2.95	3.00	2.10
12	1.95	1.55	3.27	3.35	28	1.35	3.57	2.62	2.00
13	1.65	2.85	4.85	3.05	29	1.38	3.07	2.55	2.15
14	1.53	2.95	6.07	2.90	30	1.55	2.83	2.62	2.20
15	1.45	2.47	6.88	2.85	31	.....	2.75	.....	2.10
16	1.40	1.82	6.57	2.90					

IRON RIVER DRAINAGE BASIN.

Iron River, a tributary of the Menominee system through Brule River, drains the southwest portion of Iron County, Upper Peninsula, Mich. The drainage basin is rugged; the soil is sandy and largely covered with second-growth and small timber. There are two lum-

[a] Probably including some mine pumpage.

bermen's dams, one at Iron River, about 7 miles from the mouth, and the second 7 miles farther upstream. The elevation of the stream at its confluence with Brule River is 1,400 feet and at the second dam, 14 miles upstream, 1,500 feet. The river flows through a flat valley averaging about ½ mile in width, flanked by hills 100 feet or more in height. The basin contains numerous tributary lakes, as well as a number of undrained hollows and ponds. The approximate areas of the principal lakes above Riverton Mine are given below. The aggregate water surface is 3.6 square miles.

Pond and drainage areas, Iron River Basin.

Ponds and areas.	Square miles.	Ponds and areas	Square miles.
Pickerel Lake	0.80	Other lakes and ponds	0.50
Stanley Lake	.47	Drainage area above Riverton Mine	74.6
Iron Lake	.65	Drainage area above mouth	94.7
Sunset Lake	.77		
Ice Lake	.40		

IRON RIVER AT RIVERTON MINE, MICHIGAN.

A gage was erected at the mine bridge at Riverton mine, and readings were taken, as a rule, daily by the engineers of the mine, from November 9, 1900, to July 23, 1901, inclusive. The record was again started March 1, 1902, and readings have since been taken once each day. Two readings daily were taken during March, 1902, and at times of high water. The present gage is attached vertically to a braced cedar post at the left end and the upstream side of the mine bridge. The elevation of the zero of the gage previous to October 3, 1902, was 90.95 feet; on and after October 3, 1902, it was 85 feet.

All gage readings have been converted into elevations above mine datum. The bridge from which measurements are made has a span of 30 feet between abutments. The stream does not freeze over at the gaging station. The Iron River dam for ponding logs is located 1 mile upstream from the gage. Irregular draft from the pond causes fluctuations in stage below at times; otherwise the flow is regular. The Riverton mine is situated almost directly underneath the river channel. Pumpage from the mine, which, when observed September 5, 1902, was at the rate of 1.7 second-feet, enters the stream a short distance above the gage. The record is kept under the direction of Frank Drake, chief engineer of the Oliver Iron Mining Company. The assistant engineers at Iron River mine cooperate with the United States Geological Survey in making discharge measurements.

During 1902 the following discharge measurements were made by R. E. Horton and W. V. Savicki:

September 5: Gage height, 85.95 feet; discharge, 45 second-feet.[a]
September 5: Gage height, 86.64 feet; discharge, 102 second-feet.

In 1899 a series of observations were made to determine the flow and slope from the waterworks footbridge 2,959 feet upstream to the mine bridge, which, in connection with the current-meter measurements since made, will enable the discharge to be determined. The stream in the intervening section has a uniform width and depth with earth and cobble bed. Elevations are referred to the mine datum.

Slope of Iron River near Riverton mine, Michigan.

Date.	Time.	Elevation of water at upper bridge.	Elevation of water at lower bridge.	Fall.
1899.		*Feet.*	*Feet.*	*Feet.*
July 13	8.15 a. m	93.88	85.24	8.64
July 13	10.00 a. m	93.88	83.24	8.64
July 13	11.55 a. m	93.72	85.05	8.67
July 14	8.00 a. m	93.55	84.69	8.86
July 14	1.30 p. m	93.69	84.91	8.78
July 15	8.35 a. m	93.50	84.69	8.81
July 21	1.45 p. m	93.90	85.25	8.65
July 23	7.00 p. m	94.80	86.80	8.00
August 11	9.00 a. m	93.59	84.71	8.88
August 11	11.45 a. m	93.60	84.70	8.90

Mean daily gage height, in feet, of Iron River at Riverton mine, Michigan.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1900.			1900.			1900.		
1		86.13	12	86.40	86.25	23	86.24	
2			13	86.38	86.27	24	86.25	86.33
3		86.48	14	86.25	86.27	25		
4		86.38	15	86.31	86.27	26	86.28	86.18
5		86.30	16	86.35		27	86.25	86.24
6		86.28	17	86.29	86.25	28	86.07	86.23
7		86.25	18		86.22	29		86.25
8		86.18	19	86.30	86.21	30	86.10	
9	86.07		20	86.29	86.21	31		86.18
10	81.44	86.28	21	86.35	86.20			
11		86.25	22	86.47	86.28			

[a] Stream raised by opening of storage dam above.

Mean daily gage height, in feet, of Iron River at Riverton mine, Michigan—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	86.18	86.18	86.03	86.20	87.03	86.14	86.15	.....	.....	.....	.....	.....
2	86.23	86.18	86.05	86.18	87.00	.....	86.01	.....	.....	.....	.....	.....
3	86.18	.....	86.00	86.20	86.85	86.25	86.18	.....	.....	.....	.....	.....
4	86.20	86.18	.....	86.47	86.75	86.23	87.25	.....	.....	.....	.....	.....
5	86.20	86.23	86.07	86.50	.....	86.15	87.85	.....	.....	.....	.....	.....
6	.....	86.18	86.10	86.35	86.65	86.64	87.55	.....	.....	.....	.....	.....
7	86.22	86.14	86.08	.....	86.59	86.20	.....	.....	.....	.....	.....	.....
8	86.20	86.10	86.05	86.63	86.50	86.15	87.25	.....	.....	.....	.....	.....
9	86.19	86.09	86.08	86.75	86.50	.....	87.13	.....	.....	.....	.....	.....
10	.....	.....	.....	86.90	86.50	86.42	86.65	.....	.....	.....	.....	.....
11	86.23	86.11	86.00	87.18	86.50	86.20	86.70	.....	.....	.....	.....	.....
12	86.19	86.30	86.23	87.20	.....	86.15	86.60	.....	.....	.....	.....	.....
13	.....	86.11	86.05	87.28	86.69	86.55	86.50	.....	.....	.....	.....	.....
14	86.19	86.10	86.05	.....	86.45	86.79	.....	.....	.....	.....	.....	.....
15	86.19	86.07	86.28	87.33	86.53	86.35	86.35	.....	.....	.....	.....	.....
16	86.17	86.08	86.13	87.48	86.60	.....	86.23	.....	.....	.....	.....	.....
17	86.15	.....	.....	88.25	86.55	86.25	86.33	.....	.....	.....	.....	.....
18	86.20	86.10	86.05	88.00	86.48	86.10	86.25	.....	.....	.....	.....	.....
19	86.33	86.13	86.00	87.70	.....	85.92	86.25	.....	.....	.....	.....	.....
20	.....	86.18	86.95	87.50	86.40	86.20	86.25	.....	.....	.....	.....	.....
21	86.20	86.19	.....	.....	86.35	86.20	.....	.....	.....	.....	.....	.....
22	86.15	86.09	86.08	87.10	86.40	86.60	86.60	.....	.....	.....	.....	.....
23	86.15	86.08	86.05	87.13	86.45	.....	86.40	.....	.....	.....	.....	.....
24	86.15	.....	.....	87.10	86.71	86.25	.....	.....	.....	.....	.....	.....
25	86.15	86.08	86.18	87.08	86.40	86.30	.....	.....	.....	.....	.....	.....
26	86.15	86.09	86.85	87.03	.....	86.29	.....	.....	.....	.....	.....	.....
27	.....	86.03	.....	86.95	86.30	86.43	.....	.....	.....	.....	.....	.....
28	86.15	86.15	86.20	.....	86.48	86.18	.....	.....	.....	.....	.....	.....
29	86.15	.....	86.18	86.85	86.20	86.18	.....	.....	.....	.....	.....	.....
30	86.12	.....	86.18	87.00	86.18	.....	.....	.....	.....	.....	.....	.....
31	86.12	.....	.....	.....	86.15	.....	.....	.....	.....	.....	.....	.....
1902.												
1	.....	.....	86.15	86.50	86.95	86.00	86.15	86.05	86.05	86.05	86.15	87.95
2	.....	.....	86.00	86.42	87.00	86.85	86.20	86.08	86.10	86.05	86.20	86.40
3	.....	.....	86.12	86.35	87.00	87.20	86.30	86.00	86.85	86.05	86.15	86.40
4	.....	.....	85.93	86.35	86.90	86.75	.....	85.80	85.90	86.05	86.15	86.35
5	.....	.....	86.16	86.35	86.80	86.55	86.30	85.80	85.85	86.05	86.15	86.33
6	.....	.....	86.12	86.30	87.00	86.40	.....	85.95	86.00	86.08	86.12	86.33
7	.....	.....	86.14	86.35	87.10	86.30	86.15	86.20	85.95	86.05	86.08	86.33
8	.....	.....	86.13	86.27	87.00	86.30	86.10	86.20	85.95	86.10	86.08	86.33
9	.....	.....	86.15	86.27	86.90	86.72	86.10	86.00	86.10	86.08	86.05	86.33
10	.....	.....	86.20	86.30	86.80	86.45	85.95	85.90	86.05	86.05	86.15	86.33
11	.....	.....	86.57	86.30	86.60	86.45	85.95	85.90	85.90	86.09	86.20	86.30
12	.....	.....	86.41	86.40	86.60	86.40	.....	85.85	86.10	86.08	86.35	86.30
13	.....	.....	86.30	86.30	86.60	86.45	85.85	85.90	86.05	86.10	87.18	86.30
14	.....	.....	86.33	86.25	86.50	86.42	85.90	85.85	86.00	86.10	87.27	86.30
15	.....	.....	86.43	86.30	86.50	86.30	86.00	86.20	85.85	86.05	87.05	86.30
16	.....	.....	86.30	86.20	86.50	86.22	86.10	86.10	87.55	86.05	86.40	86.30
17	.....	.....	86.25	86.25	86.45	86.25	86.00	86.00	87.00	86.10	86.35	86.30
18	.....	.....	86.23	86.30	86.35	86.22	86.00	85.90	85.85	86.09	86.33	86.30
19	.....	.....	86.28	86.25	86.30	86.22	86.00	85.95	85.50	86.08	86.33	86.30
20	.....	.....	86.25	86.20	86.33	86.20	86.10	86.00	85.80	86.08	86.33	86.32
21	.....	.....	86.25	86.22	86.40	86.25	86.20	86.20	.....	86.08	86.33	86.32

Mean daily gage height, in feet, of Iron River at Riverton mine, Michigan—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
22	.....	.....	86.28	86.25	86.40	86.22	86.45	85.90	86.80	86.08	86.33	86.32
23	.....	.....	.....	86.45	86.35	86.20	86.10	85.95	86.55	86.09	86.33	86.32
24	.....	.....	86.50	86.40	86.35	86.25	86.10	85.85	85.80	86.80	86.33	86.32
25	.....	.....	86.55	86.30	.....	86.30	86.10	85.95	86.00	86.25	86.33	86.32
26	.....	.....	86.69	87.25	86.10	86.52	86.00	86.00	86.00	86.25	86.33	86.32
27	.....	.....	86.63	87.55	86.10	86.20	86.00	85.90	86.05	86.25	86.33	86.32
28	.....	.....	86.68	87.50	86.00	86.20	85.95	85.90	.....	86.20	86.33	86.30
29	.....	.....	86.68	87.35	86.00	.....	85.95	86.10	86.05	86.20	86.33	86.30
30	.....	.....	86.62	86.13	86.12	86.15	86.10	86.90	86.05	86.20	86.33	86.30
31	.....	.....	86.55	.....	86.05	.....	86.05	86.70	.....	86.20	.....	86.35

ST. JOSEPH RIVER DRAINAGE BASIN.

St. Joseph River rises at Bunday Hills, in northern Hillsdale County, Mich., flows southwesterly into Indiana, turns northward at South Bend, recrosses the State line near Bertrand, and debouches into Lake Michigan at St Joseph. The total area drained is approximately 4,586 square miles, of which 2,916 square miles are in Michigan and 1,670 square miles in Indiana. The drainage basin contains more than 400 small lakes, varying in surface area from an eighth of a square mile to 6 square miles. Of these, approximately 100 are in Indiana and 300 in Michigan. No storage is developed on the stream.

The drainage basin lies in a completely glaciated region, and is overlain with diversified drift deposits. The current of the river from South Bend to its mouth was formerly reversed, and this valley formed an outlet for the waters of Lake Michigan, which turned to the southwest, through Kankakee River, at South Bend, and thus reached the Mississippi through Illinois River.

The basin of St. Joseph River in Michigan contains relatively little marsh land not artificially drained and relatively little uncleared land. About a third of the lakes are, however, without outlets. The proportion of undrained lakes in Indiana is smaller, and the swamp lands are much more extensive.

Elkhart River, one of the principal Indiana tributaries of the St. Joseph, drains an area of about 500 square miles which contains large lakes and extended swamp areas, with the principal fall occurring in the passage of the stream from marsh to marsh.

ST. JOSEPH RIVER AT BUCHANAN, MICH.

A gaging station was established on St. Joseph River at the dam of the Buchanan Electric Light and Power Company, 1 mile below the village of Buchanan, April 1, 1901. The dam is of frame timber of the Beardsley type, 10 feet high, and rests on earth foundation, leakage

being prevented by means of triple sheet piling at the downstream toe. The upstream face of the dam has a slope of approximately 2.4 horizontal to 1 vertical. The downstream side is also faced with a sloping apron, the two slopes meeting at the crest at an angle of 90°. The dam is level and 392.5 feet in length. The crest gage is attached to piling 45 feet upstream from the crest, and is read at 7.30 a. m. and 5.30 p. m. each day by Charles E. Babcock.

The discharge over the dam has been calculated by the weir formula, using coefficients derived from experiments at Cornell University on a weir of the same form of cross section.

At the right-hand side of the stream is situated the Buchanan electric-light plant, containing three special 48-inch New American turbines, 1895 model. These are controlled by a single Woodward governor, and a record is kept of the number of hours per day the wheels are run and the average opening of the speed gate.

On the left-hand side of the dam are two 35-inch Leffel turbines in separate vertical cylinder cases connected to a single governor; from them power is transmitted to adjacent mills by manila rope. A record is also kept of the daily operation of these turbines by Charles E. Kissenger. The average working head on the water wheels is 11.25 feet. A small amount of leakage through the dam existed in 1901, which has not been estimated.

The record at Buchanan is kept through the cooperation of Hugh H. Hosford, superintendent of the electric light and power plant. The accompanying tables show the estimated daily discharge and monthly run-off at the dam. August 21, 1902, a discharge measurement of St. Joseph River at Niles, 4 miles above Buchanan, showed the flow to be 2,217 second-feet, or 0.613 second-feet per square mile from the tributary drainage area of 3,616 square miles.

Mean daily discharge, in second-feet, of St. Joseph River at Buchanan, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	.....	.....	.....	7,476	3,913	2,693	1,943	1,449	1,383	1,670	2,648	2,548
2	.....	.....	.....	7,212	3,693	2,476	1,943	1,453	1,817	1,670	2,712	3,017
3	.....	.....	.....	6,532	3,414	2,432	1,812	1,456	1,588	1,670	2,478	3,891
4	.....	.....	.....	6,196	3,285	2,430	1,745	1,248	1,588	1,670	2,785	2,766
5	.....	.....	.....	6,099	3,066	2,384	2,060	1,328	1,769	1,664	2,839	2,782
6	.....	.....	.....	5,860	3,081	2,308	2,191	1,335	1,817	1,442	2,839	2,766
7	.....	.....	.....	5,409	3,293	2,188	1,980	1,335	1,709	1,740	2,712	2,639
8	.....	.....	.....	5,528	3,429	2,064	2,122	1,456	1,748	1,861	2,775	2,471
9	.....	.....	.....	5,444	3,361	1,980	2,499	1,342	1,769	1,922	2,844	2,687
10	.....	.....	.....	5,343	3,344	2,064	1,878	1,335	1,896	1,984	2,478	2,954
11	.....	.....	.....	5,201	3,358	2,060	1,936	1,037	1,834	2,046	2,585	3,018
12	.....	.....	.....	4,875	3,233	2,067	1,812	1,169	1,834	2,040	2,839	2,742
13	.....	.....	.....	4,658	3,350	2,060	1,812	1,122	1,834	2,301	2,966	2,869
14	.....	.....	.....	4,393	3,146	2,064	1,730	1,028	1,834	3,929	2,966	2,757
15	.....	.....	.....	4,295	3,017	1,936	1,941	1,276	1,380	4,505	2,966	4,333

Mean daily discharge, in second-feet, of St. Joseph River at Buchanan, Mich.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
16	.....	.....	.....	4,216	2,883	1,729	1,876	1,127	1,471	4,577	2,966	3,888
17	.....	.....	.....	4,148	2,570	1,751	1,753	1,127	1,652	4,289	2,106	3,477
18	.....	.....	.....	4,442	2,566	2,126	1,635	1,138	1,896	3,997	2,966	3,205
19	.....	.....	.....	4,419	2,490	2,002	1,629	1,826	1,821	3,927	2,839	2,933
20	.....	.....	.....	4,439	2,643	1,936	1,624	1,826	1,883	3,740	2,966	2,933
21	.....	.....	.....	4,461	2,763	1,881	1,613	1,826	1,821	3,853	2,966	3,137
22	.....	.....	.....	4,583	2,573	1,936	1,693	1,598	1,743	3,991	2,902	3,205
23	.....	.....	.....	4,726	2,490	1,725	1,630	1,700	2,154	3,447	2,839	3,328
24	.....	.....	.....	4,888	2,566	1,755	1,570	1,765	2,160	3,173	2,490	2,619
25	.....	.....	.....	4,888	2,700	1,816	1,390	1,377	1,912	3,109	2,753	3,880
26	.....	.....	.....	4,875	2,617	1,816	1,390	2,074	1,918	2,959	3,017	3,952
27	.....	.....	.....	4,733	2,827	1,940	1,511	2,012	1,912	2,946	3,144	3,924
28	.....	.....	.....	4,317	2,820	2,184	1,102	2,074	1,851	2,702	2,890	4,024
29	.....	.....	.....	4,288	2,814	2,058	1,330	2,081	1,790	2,705	2,636	3,593
30	.....	.....	.....	4,273	2,617	1,856	1,572	1,954	1,428	2,701	2,636	3,816
31	.....	.....	.....	.....	2,750	.....	1,574	1,830	.....	2,708	.....	3,667
Mean	.....	.....	.....	5,074	2,990	2,057	1,750	1,507	1,774	2,804	2,785	3,220
1902.												
1	3,260	2,174	4,411	4,961	2,933	5,940	5,772	3,409	1,665	4,045	2,425	3,205
2	3,137	2,161	6,192	4,961	2,937	5,785	6,024	3,205	1,740	4,045	2,539	3,273
3	3,069	2,302	6,293	4,801	2,679	5,281	5,940	3,192	1,802	4,045	2,679	3,341
4	3,001	2,429	5,537	4,645	2,412	4,645	5,856	3,001	1,678	3,901	2,806	3,341
5	2,920	2,429	4,961	4,489	3,208	4,189	5,688	2,806	1,557	3,888	2,933	3,205
6	2,933	2,495	4,649	4,476	3,072	3,685	5,604	2,679	1,436	4,045	3,069	3,192
7	2,069	2,556	4,415	4,411	3,904	3,205	5,449	2,679	1,544	4,045	3,205	3,192
8	2,933	2,679	4,333	4,337	4,336	3,192	5,197	2,615	1,678	3,901	3,205	3,341
9	2,933	2,793	4,320	4,193	4,336	3,757	4,957	2,552	1,802	3,757	2,920	3,341
10	2,933	2,810	4,195	4,049	4,333	3,685	4,801	2,488	1,926	3,757	3,001	3,341
11	2,806	2,810	4,339	3,689	3,744	2,205	4,489	2,425	1,926	3,757	3,205	3,341
12	2,793	2,746	5,372	3,477	3,977	3,069	4,333	2,425	2,040	3,600	3,205	3,477
13	2,933	2,683	6,545	3,464	3,689	3,069	4,176	2,425	2,174	3,477	3,341	3,477
14	2,933	2,683	6,545	3,413	3,409	3,205	4,045	2,361	2,161	3,409	3,341	3,464
15	2,933	2,488	6,457	3,345	3,209	3,396	3,757	2,298	2,174	3,273	3,341	3,545
16	2,933	2,412	6,276	3,141	3,209	3,757	3,477	2,174	2,174	3,205	3,464	3,613
17	2,933	2,302	6,205	2,937	3,205	3,685	3,477	2,161	2,298	3,205	3,477	3,613
18	2,806	2,302	6,037	2,810	2,666	3,409	3,202	2,174	2,298	3,205	3,477	3,613
19	2,412	2,178	5,785	2,806	3,209	3,341	3,613	2,174	2,298	3,192	3,341	3,829
20	2,298	2,178	5,537	2,729	3,073	3,205	4,032	2,174	2,298	3,056	3,205	4,117
21	2,425	2,178	5,173	2,683	2,937	3,273	4,333	2,174	2,161	3,069	3,205	4,476
22	2,425	2,050	4,957	2,683	2,937	3,464	4,338	2,174	2,298	3,069	3,205	5,113
23	2,552	2,161	4,944	2,683	2,810	3,341	4,045	2,174	2,425	2,933	3,464	6,289
24	2,556	2,240	4,805	2,683	2,933	3,273	4,045	2,037	2,615	2,933	3,341	5,869
25	2,552	2,492	4,805	2,746	4,032	3,137	3,757	2,174	2,742	2,806	3,137	5,268
26	2,475	2,621	4,649	2,933	5,369	3,001	3,613	2,174	3,137	1,665	3,001	4,723
27	2,429	3,347	4,649	2,927	6,125	2,933	3,192	2,050	2,933	2,679	2,920	4,645
28	2,365	1,808	4,571	3,209	6,377	3,001	3,477	1,988	3,260	2,552	3,069	4,710
29	2,240	.....	4,489	3,205	6,298	3,260	3,477	1,864	3,829	2,552	3,069	4,723
30	2,178	.....	4,710	2,933	6,283	4,489	3,409	1,802	3,973	2,552	3,124	4,411
31	2,178	.....	4,961	.....	6,121	.....	3,205	1,665	.....	2,425	.....	4,117
Mean	2,721	2,446	5,197	3,560	3,863	3,629	4,347	2,377	2,268	3,291	3,124	3,974

Estimated monthly discharge of St. Joseph River at Buchanan, Mich.

[Drainage area, 3,935 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
April	7,476	4,148	5,074	1.29	1.44
May	3,913	2,490	2,990	.76	.87
June	2,693	1,725	2,057	.53	.59
July	2,499	1,102	1,750	.45	.52
August	2,081	1,028	1,507	.38	.44
September	2,160	1,380	1,774	.45	.50
October	4,577	1,442	2,804	.71	.82
November	2,966	2,478	2,785	.70	.78
December	4,333	2,471	3,220	.82	.94
1902.					
January	3,260	2,178	2,721	.69	.79
February	3,347	1,808	2,446	.62	.64
March	6,545	4,195	5,197	1.32	1.52
April	4,961	2,683	3,560	.90	1.00
May	6,377	2,666	3,863	.98	1.13
June	5,940	2,205	3,629	.92	1.02
July	6,024	3,192	4,347	1.10	1.27
August	3,409	1,665	2,377	.60	.69
September	3,973	1,436	2,268	.58	.64
October	4,045	1,665	3,291	.84	.97
November	3,477	2,425	3,124	.79	.88
December	6,289	3,192	3,974	1.00	1.15
The year	6,545	1,436	3,400	.86	11.70

ST. JOSEPH RIVER AT MENDON, MICH.

A gaging station was established at the Maranteke bridge on the south line of sec. 33, T. 5 S., R. 10 W., October 25, 1902. This bridge is located about one-half mile downstream from the gage, which is in the village of Mendon. The bridge has a single span of 136.5 feet between abutments, stands squarely across the direction of the current, and affords a fairly permanent cross section for gaging, the bed being of smooth clay. There is a bend in the stream a short distance above this bridge. The channel below for some distance is

straight. The gage is a vertical scale attached to a braced cedar post near the water's edge. Its datum is elevation 80.04 feet, or 19.95 feet below the bench mark, which is the top of the head of a spike driven into the brick wall at the southeast corner of Masonic Hall building, 150 feet northwest from the gage.

Little Portage River flows parallel to and about 1 mile distant from St. Joseph River at Mendon, and was at one time diverted across the divide, affording water power with a fall of 20 feet. This has been discontinued. Franchises have been granted for a number of water powers on St. Joseph River in this locality:

(1) Michigan Hydraulic Company at Colon, Mich., 18 feet fall at dam under construction.
(2) Michigan Hydraulic Company, 4 miles below Colon, 8 feet fall obtainable.
(3) W. P. McCoy, Mendon, Mich., 8 feet fall.
(4) Site, 3 miles below Mendon; stated fall, 7 feet.
(5) Seven miles below Mendon; 18 feet fall claimed.

The drainage area above Maranteke bridge is 844 square miles. The gage is read twice each day by William P. McCoy. The means of the daily gage readings are given in the accompanying table.

During 1902 the following discharge measurements were made by R. E. Horton and W. V. Savicki:

August 21: Gage height, —[a]; discharge, 406 second-feet.
October 12: Gage height, 1.9 feet; discharge, 786 second-feet.

Mean daily gage height, in feet, of St. Joseph River at Mendon, Mich.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902			
1	.....	1.30	1.20	12	.....	1.60	1.50	23	.....	1.40	2.60
2	.....	1.30	1.25	13	.....	1.50	2.80	24	.....	1.40	2.58
3	.....	1.28	1.30	14	.....	1.50	1.80	25	.....	1.30	2.50
4	.....	1.28	1.43	15	.....	1.45	1.60	26	1.40	1.25	2.20
5	.....	1.30	1.60	16	.....	1.45	1.50	27	1.43	1.25	2.18
6	.....	1.40	1.70	17	.....	1.50	1.70	28	1.43	1.30	2.10
7	.....	1.35	1.70	18	.....	1.50	1.65	29	1.45	1.30	2.00
8	.....	1.53	1.70	19	.....	1.50	1.60	30	1.40	1.30	2.00
9	.....	1.60	1.58	20	.....	1.50	1.65	31	1.40	.....	3.40
10	.....	1.60	1.53	21	.....	1.40	1.70				
11	.....	1.60	1.50	22	.....	1.40	2.50				

KALAMAZOO RIVER DRAINAGE BASIN.

Kalamazoo River rises in the south-central part of the Lower Peninsula of Michigan and flows in a northwesterly direction, debouching into Lake Michigan 3¼ miles below the village of Saugatuck. Its current is slow, averaging about 3 miles an hour, and its slope uniform, there being no waterfalls and no considerable rapids except at two

[a] Gage not installed.

points, at each of which there occurs a descent of 3 or 4 feet within a distance of a few rods. The river flows through a rich agricultural region, in a valley from one-fourth of a mile to 2 or 3 miles in width, backed by low hills or sloping gently to the upland. The flat lands in the valley are often flooded and serve largely as permanent meadows through which the river winds, often in a very tortuous manner. Two branches unite at Albion to form the main stream. The total length from the point of juncture to the outlet is 101 miles.

In respect to the climate, topography, and run-off of its drainage basin, Kalamazoo River may be considered as typical of the larger streams of southern Michigan, including the Grand, the St. Joseph, and the Raisin, all of which find their sources within a few miles of each other and of the Kalamazoo. The drainage area covers 1,750 square miles. A detailed description of a part of Lower Kalamazoo Basin is given in the third report, Bureau of Soils, Department of Agriculture, pages 93–124.

KALAMAZOO RIVER NEAR ALLEGAN, MICH.

A gaging station was established at the dam of the Kalamazoo Valley Electric Company, Trowbridge Township, 6 miles upstream by river from Allegan, April 4, 1901. The dam is of timber crib work filled with stone, resting on pile foundation in clay hardpan. The dam is equipped with three Taintor segmental flood gates, each of 19.7 feet clear width. In the adjacent power house, forming a portion of the dam, are eight 43-inch Leffel-Samson turbines arranged in two sets on a horizontal shaft, each set controlled by a separate governor. The gaging record includes the number of hours of daily run; the average gate opening of the turbines, as indicated by the index wheels of the governors; the stage of water on the tailrace gage; and the reading of the crest gage. The crest gage is set with its zero at the elevation of the horizontal spillways of 20 feet crest width each, which are closed by the Taintor gates. The crest gage also serves to show the depth flowing over the crests of the Taintor gates or of flashboards placed thereon. A record of the opening and closing of the Taintor gates is also kept. The pond above the dam covers an area of 1,000 acres. The turbines run continuously and the flow of the stream is nearly all utilized, except in times of extreme freshet. At such times the water level is controlled by means of the flood gates described.

The crest and tailrace gages are set with a difference of elevation of 12 feet, and both are referred to the top of the masonry pier at the entrance to the flume as a bench mark.

The elevation of the zero of the crest gage is 83.95 feet; that of the zero of the tailrace gage, 71.95 feet.

The effective head varies from 21 to 23 feet. The record is maintained in cooperation with the Kalamazoo Valley Electric Company.

The gages were set under the direction of H. C. Hoagland, superintendent. The power plant contains a 1,500-kilowatt multipolar generator, and the power is used for long-distance transmission to drive interurban electric railroads. The Kalamazoo Valley Electric Company contemplates the erection of other similar power plants both above and below the present plant, in the near future. A test by current meter, at the highway bridge, just below the dam, was made on August 22, 1902, with results as follows:

Head on turbines	feet	21.9
Discharge of four turbines, 0.1 to 0.3 gate	second-feet	223.8
Discharge of four turbines, 0.5 to 0.6 gate	do	470
Flow over spillways	do	61.7
Leakage	do	5
Total estimated discharge	do	760.5
Discharge measured by current meter	do	785.1

A measurement of the high-water discharge of North Branch Kalamazoo River at Albion, Mich., March 9, 1903, at the electric railroad bridge, showed the flow to be 232 second-feet, or 1.68 second-feet per square mile from the tributary drainage area of 138 square miles.

The following tables give the result of a series of flood measurements of Kalamazoo River made by William G. Fargo, C. E., of Jackson, Mich. In each case a number of floats were run to determine the maximum surface velocity, and soundings were taken in the float sections to determine the cross-sectional area. The first table gives the results of gagings at the highway bridge just below the Trowbridge dam, on the west line of sec. 12, T. 1 N., R. 13 W. The second table gives the results of similar measurements near the north-south line of sec. 22, T. 2 S., R. 7 W. (Emmet Township, 3 miles below Ceresco village). The drainage area at this point is 489 square miles.

Discharge measurements of Kalamazoo River above Allegan, Mich.

Measurements.	Mar. 21, 1897.	May 19, 1897.	Oct. 7, 1897.	May 12, 1898.
Width of section ... feet	154	154	154	154
Area of section ... square feet	746	510	338	422.2
Central surface velocity per second ... feet	4.10	2.95	2.35	2.78
Mean velocity coefficient	.83	.83	.83	.83
Mean velocity per second ... feet	3.40	2.45	1.95	2.3
Discharge ... second-feet	2,536	1,249.5	659.1	970.1
Discharge per square mile ... do	1.72	.85	4.48	.66

Discharge measurements of Kalamazoo River 3 miles below Ceresco, Mich.

Measurements.		May 22, 1897.	Dec. 8, 1897.
Area cross-section	square feet	261	204
Central surface velocity per second	feet	2.21	1.64
Mean velocity coefficient		.83	.83
Mean velocity per second	feet	1.83	1.36
Discharge	second-feet	478.5	277.4
Discharge per square mile	do	.97	.56

The following tables give the daily discharge and run-off at the Trowbridge dam:

Mean daily discharge, in second-feet, of Kalamazoo River at Trowbridge dam, near Allegan, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	.....	.....	.....	.....	874	785	852	822	823	404	861	637
2	.....	.....	.....	.....	933	850	844	856	803	674	845	837
3	.....	.....	.....	.....	907	926	766	828	810	578	721	747
4	.....	.....	.....	1,013	863	801	778	784	852	478	845	762
5	.....	.....	.....	1,041	730	813	777	872	811	369	803	746
6	.....	.....	.....	1,001	845	812	647	876	590	172	845	739
7	.....	.....	.....	1,027	870	802	797	883	606	511	967	754
8	.....	.....	.....	998	847	808	102	816	570	408	1,011	739
9	.....	.....	.....	1,003	863	814	689	804	570	525	946	798
10	.....	.....	.....	1,009	863	814	663	799	648	482	987	786
11	.....	.....	.....	977	846	808	647	660	594	713	987	814
12	.....	.....	.....	825	900	845	738	598	829	743	889	865
13	.....	.....	.....	870	890	845	888	660	829	879	912	857
14	.....	.....	.....	888	895	837	420	660	829	1,041	1,008	979
15	.....	.....	.....	878	849	861	880	694	782	892	823	824
16	.....	.....	.....	858	790	822	841	514	829	940	891	821
17	.....	.....	.....	1,004	790	853	859	625	857	996	751	698
18	.....	.....	.....	1,015	800	837	858	727	844	838	904	700
19	.....	.....	.....	952	652	829	823	726	829	838	790	631
20	.....	.....	.....	914	645	861	829	799	791	690	764	816
21	.....	.....	.....	939	645	861	759	804	811	729	694	846
22	.....	.....	.....	939	645	867	753	799	504	877	761	839
23	.....	.....	.....	983	686	829	747	796	510	841	777	959
24	.....	.....	.....	911	666	833	741	794	736	858	777	893
25	.....	.....	.....	905	716	806	753	624	836	988	829	781
26	.....	.....	.....	894	760	914	844	874	693	907	777	868
27	.....	.....	.....	926	645	847	852	848	788	967	761	888
28	.....	.....	.....	961	650	771	696	802	785	975	813	818
29	.....	.....	.....	836	650	986	860	829	.....	967	869	668
30	.....	.....	.....	813	650	773	827	837	.....	879	822	850
31	.....	.....	.....	.....	701	.....	800	804	.....	882	.....	813
Mean	.....	.....	.....	940	776	837	752	768	741	741	847	799

Mean daily discharge, in second-feet, of Kalamazoo River at Trowbridge dam, near Allegan, Mich.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	687	858	957	915	711	710	956	843	723	919	892	1,063
2	733	837	817	915	780	812	1,008	843	723	964	773	1,120
3	748	860	945	907	768	812	1,041	711	731	909	905	1,120
4	694	636	822	891	807	648	1,026	771	632	932	934	1,061
5	673	591	739	878	795	749	1,123	863	803	777	995	1,070
6	764	612	739	763	907	880	1,072	847	822	856	973	1,079
7	772	655	829	867	931	817	1,072	871	749	942	965	840
8	722	553	829	850	873	728	981	821	696	906	900	1,088
9	741	560	637	869	876	838	1,089	902	788	874	873	1,074
10	729	679	867	862	831	805	1,067	711	845	926	988	1,040
11	738	793	945	867	790	743	990	807	837	928	988	1,079
12	686	751	913	854	854	743	992	839	837	716	924	991
13	673	697	935	786	869	797	839	888	884	959	862	983
14	801	697	924	840	848	925	851	786	250	952	996	721
15	657	682	960	851	855	776	850	788	708	913	964	934
16	514	667	798	771	844	844	699	834	647	921	817	967
17	729	524	863	762	825	767	904	681	612	929	929	85
18	715	705	827	843	710	855	807	782	612	921	926	989
19	715	593	747	835	811	789	847	791	621	724	918	1,016
20	715	553	807	635	831	897	863	763	564	916	926	1,118
21	696	613	890	776	751	853	806	786	545	950	843	804
22	682	621	898	867	806	789	814	787	810	902	1,020	964
23	682	834	748	739	801	839	794	844	897	926	796	970
24	619	579	827	778	819	834	847	699	921	932	989	901
25	682	729	867	781	824	802	859	769	929	988	967	930
26	554	758	851	822	801	1,046	903	846	972	785	1,049	926
27	837	758	875	698	827	1,178	817	838	972	898	805	736
28	438	729	953	757	801	875	898	831	807	923	987	650
29	521	.....	898	731	801	758	898	748	925	944	991	857
30	612	.....	820	660	737	949	892	757	972	926	820	934
31	612	.....	900	.....	817	.....	882	680	.....	807	.....	987
Mean	681	683	852	812	816	828	918	797	761	900	923	938

Estimated monthly discharge of Kalamazoo River at Trowbridge dam, Michigan.

[Drainage area, 1,471 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
April	1,041	813	940	0.64	0.71
May	933	645	776	.53	.61
June	986	771	837	.57	.64
July	888	102	752	.51	.59
August	883	514	768	.52	.60
September	857	504	741	.50	.56
October	1,041	172	741	.50	.58
November	1,011	721	847	.57	.64
December	979	631	799	.54	.62
1902.					
January	837	438	681	0.46	0.53
February	860	524	683	.46	.48
March	960	637	852	.58	.67
April	915	635	812	.55	.62
May	931	710	816	.55	.64
June	1,178	648	828	.56	.63
July	1,123	699	918	.62	.72
August	902	680	797	.54	.62
September	972	250	761	.52	.58
October	988	716	900	.61	.70
November	1,049	773	923	.63	.70
December	1,120	85	938	.64	.73
The year	1,178	85	826	.56	7.62

GRAND RIVER DRAINAGE BASIN.

This is the largest stream in Michigan. Its drainage basin, which includes a total area of 5,572 square miles, is situated in the central portion of the lower peninsula, and drains into Lake Michigan. It lies in the southern border of the pine belt, and is for the most part cleared. Occasional tracts of forest remain. The basin receives an annual rainfall varying from 25 inches in the region of the headwaters to 30 or 35 inches near the mouth of the river.

The drainage basin is comparatively flat. The total fall of the river from the extreme headwaters to the mouth, a distance of more than 200 miles, is about 350 feet.

The northwestern and southeastern portions of the basin are thickly interspersed with small lakes. A considerable number of these have no surface outlets, and their drainage basins do not contribute to the run-off of the river except through ground water.

GRAND RIVER AT GRAND RAPIDS, MICH.

A gaging station was established at the Fulton street bridge, Grand Rapids, March 12, 1901, and a record of the stage of the stream at this and other gages in the city has been maintained by L. W. Anderson, city engineer. The accompanying table gives the results of discharge measurements made by Charles Redman, C. E. The gage is attached to the upstream end of the ice breaker of the left-hand bridge pier and has its zero at elevation 0.55 feet below the city datum. All gage readings, as well as the stream stage given in the table of discharge measurements, have been reduced to elevations above city datum. The direction of the current makes an angle of 10° 15′ with the bridge from which discharge measurements have been taken. The discharge measurements have been made with a large Price meter, No. 88, by the 0.6 depth method. A rating curve has been prepared and the daily discharge and run-off have been calculated, as given in the accompanying tables.

The mean daily readings at Wealthy avenue gage, situated below the Fulton street station, are also given. These readings were taken on the United States engineers' gage, which has its datum 7.38 feet below Grand Rapids city datum.

Discharge measurements of Grand River at Fulton street bridge, Grand Rapids, Mich.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Second-feet.*
March 15	Charles Redman	3.73	6,033
March 16	do	4.13	6,035
March 18	do	4.96	7,830
March 22	do	9.87	18,146
March 23	do	10.47	20,324
April 8	do	3.86	7,234
April 11	do	2.79	5,759
April 13	do	2.18	4,783
May 3	do	1.34	3,863
June 3	do	.46	2,847
June 28	do	- .15	1,749
September 27	do	- .30	1,466
October 8	do	— .45	1,276
1902.			
April 3	do	--5.17	9,305

Mean daily gage height, in feet, of Grand River at Fulton street, Grand Rapids, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	0.57	0.06	3.32	4.60	1.20	.....	1.44	1.84	0.80	2.40	0.95	1.13
2	.52	-.16	3.71	5.02	1.02	0.55	1.86	1.68	.55	2.40	.....	1.13
3	.79	.16	3.82	5.16	1.01	.60	5.68	.....	.70	2.30	.78	1.50
4	.67	.08	3.90	5.02	1.11	.71	6.78	1.46	.53	2.15	.83	1.95
5	.54	.16	3.63	4.63	1.65	.85	7.15	1.30	.28	.....	1.08	2.35
6	.69	.20	3.19	4.32	1.99	.72	.....	1.08	.36	.....	2.20	2.65
7	.39	.21	2.56	3.95	3.54	.84	7.24	.97	.....	1.28	2.80	.....
8	.26	.10	2.31	3.69	4.64	.....	7.25	.80	.54	1.28	3.35	2.00
9	.26	-.07	2.10	3.34	4.96	.89	7.40	.58	.63	1.35	.....	1.60
10	.30	.22	1.75	3.03	5.37	1.29	6.89	.....	.45	1.28	3.10	1.45
11	.34	.08	1.71	2.76	5.21	1.41	6.02	.46	.58	1.15	2.80	1.43
12	.25	-.03	2.57	2.48	4.90	1.32	5.06	.42	.48	.....	2.58	1.23
13	.47	.03	5.45	2.12	4.45	1.16	.....	.40	.70	1.88	2.35	1.20
14	.28	-.04	5.96	1.90	4.09	1.20	3.69	.25	.....	2.03	2.25	.....
15	.28	-.07	6.15	1.76	3.68	.....	3.17	.13	.70	2.13	2.45	1.10
16	.20	-.28	6.24	1.44	3.34	1.93	2.80	.13	.75	1.95	.....	1.28
17	.30	.08	5.97	1.23	2.95	2.04	2.44	.....	.70	1.68	2.45	1.45
18	.00	-.11	5.47	1.17	.....	1.95	2.26	.05	.60	1.45	2.43	1.48
19	-.08	-.06	5.26	.98	2.85	1.76	2.26	.18	.50	.....	2.33	1.53
20	.08	-.21	4.25	.84	2.83	1.65	.....	.22	.48	1.23	2.23	1.80
21	-.17	-.20	3.86	.75	2.74	1.55	2.79	.18	.....	1.08	2.18	.....
22	-.21	-.21	3.52	.71	2.68	.....	3.08	.18	.50	1.05	2.08	3.65
23	.19	-.26	3.13	.60	2.59	1.15	3.40	.22	.40	1.08	.....	3.93
24	-.10	.00	2.87	.51	2.55	1.02	3.48	.....	.21	1.05	1.93	3.63
25	.19	-.19	2.52	.44	.....	1.01	3.21	.26	.35	1.05	1.80	.....
26	-.27	.06	2.31	.58	1.98	.92	3.14	.20	.54	.....	1.53	3.38
27	.50	.38	2.03	.89	1.63	.85	.....	.38	1.28	1.10	.....	2.90
28	.65	1.71	1.99	1.33	1.30	.64	2.71	.43	.....	1.10	1.18	.....
29	.37	.....	2.20	1.50	1.02	.....	2.51	.43	1.93	1.10	1.13	2.50
30	.27	.....	2.79	1.43	1.00	.97	2.33	.43	2.00	1.10	.....	2.58
31	.09	.....	3.65	.....	.55	.....	2.09	.....	.....	1.00	.....	2.60

Mean daily gage height, in feet, of Grand River at Wealthy avenue, Grand Rapids, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.39	6.65	10.52	11.64	8.10	.....	8.33	8.86	5.53	9.33	7.88	8.08
2	7.42	6.41	10.86	12.08	7.90	7.35	8.80	8.86	5.66	9.40	.....	8.08
3	7.67	6.71	10.92	12.20	7.83	7.45	12.79	.....	5.53	9.25	7.73	8.45
4	7.48	6.59	10.95	12.06	7.98	7.55	13.93	8.47	5.78	9.10	7.78	8.90
5	7.30	6.51	10.74	11.65	8.05	7.71	14.25	8.31	5.86	.....	8.03	9.30
6	7.44	6.42	10.21	11.34	8.93	7.54	.....	8.09	5.95	.....	9.15	9.60
7	7.22	6.57	9.61	11.08	10.54	7.70	14.33	8.00	.....	8.23	9.75	.....
8	7.13	6.59	9.34	10.66	11.69	.....	14.38	7.78	5.75	8.20	10.28	8.95
9	7.11	6.47	9.08	10.35	12.06	7.73	14.54	7.54	5.84	8.28	.....	8.55
10	7.12	6.69	8.71	10.02	12.42	8.19	14.04	.....	5.83	8.28	10.05	8.40
11	7.23	6.52	8.65	9.74	12.26	8.31	13.13	7.44	5.71	8.10	9.75	8.35
12	7.22	6.46	9.55	9.47	11.95	8.17	11.77	7.33	5.73	.....	9.53	8.18
13	7.29	6.45	12.56	9.14	11.50	8.05	.....	7.20	5.72	8.80	9.30	8.15
14	7.15	6.44	13.13	8.88	11.13	8.06	10.75	7.06	.....	9.00	9.22	.....
15	7.05	6.39	13.22	8.70	10.70	.....	10.28	6.93	5.49	9.13	9.40	.....
16	6.96	6.18	13.33	8.40	11.36	8.82	9.95	6.88	5.52	8.90	.....	.....
17	6.87	6.61	13.08	8.19	9.93	8.98	9.59	.....	5.50	8.68	9.38	.....
18	6.80	6.50	12.55	8.07	.....	8.87	9.29	6.60	5.53	8.40	9.40	.....
19	6.60	6.55	11.84	7.84	9.85	8.68	9.33	6.56	5.69	.....	9.28	.....
20	6.75	6.29	11.30	7.65	9.87	8.59	.....	6.49	5.89	8.15	9.18	.....
21	6.65	6.38	10.92	7.72	9.69	8.50	9.77	6.44	.....	7.98	9.13	.....
22	6.53	6.30	10.53	7.59	9.64	.....	10.08	6.38	5.73	7.98	9.03	.....
23	6.47	6.61	10.13	7.46	9.58	8.01	10.41	6.32	5.98	8.08	.....	.....
24	6.55	6.84	9.90	7.33	9.54	7.89	10.52	.....	6.71	8.03	8.88	.....
25	6.41	6.74	9.52	7.24	.....	7.88	10.29	6.18	7.09	8.00	8.70	.....
26	6.27	6.79	9.26	7.38	8.95	7.74	10.16	6.22	7.39	.....	8.48	.....
27	6.40	7.23	9.00	7.71	8.56	7.63	.....	6.05	8.14	8.05	.....	.....
28	7.57	8.79	8.94	8.20	8.23	7.50	9.77	5.97	.....	8.05	8.13	.....
29	7.21	.....	9.18	8.43	7.93	.....	9.58	5.90	8.85	8.05	8.08	.....
30	6.94	.....	9.83	8.35	7.74	7.88	9.44	5.84	8.93	8.05	.....	.....
31	6.80	.....	10.68	.....	7.40	.....	9.18	.....	.....	7.95	.....	.....

Mean daily discharge, in second-feet, of Grand River at Fulton street, Grand Rapids, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1				18,255	4,240	2,810	2,332	2,810	3,008	1,500	2,076	1,884
2				15,556	3,960	2,546	2,076	2,744	2,678	1,538	2,076	2,142
3				13,380	3,536	2,480	2,076	2,398	2,332	1,628	1,948	2,076
4				11,500	3,272	2,480	1,666	2,076	2,204	1,500	2,076	1,948
5				9,770	3,074	2,398	8,488	2,332	2,014	1,396	2,014	1,729
6				8,565	2,876	2,332	11,680	1,692	1,820	1,206	2,014	1,436
7				7,805	2,678	2,204	11,950	1,948	1,742	1,436	2,948	1,372
8				7,280	2,942	2,014	11,382	1,884	1,564	1,372	2,014	1,410
9				6,680	3,140	1,756	10,268	1,820	1,500	1,372	1,884	2,014
10				6,179	3,536	1,860	8,719	1,756	1,500	1,334	1,756	2,014
11				5,814	3,744	2,204	7,205	1,110	1,666	1,436	1,948	2,076
12			4,240	5,303	4,176	2,201	7,355	1,732	2,146	1,604	2,076	2,142
13			5,010	4,800	4,176	2,480	4,940	1,666	2,332	1,500	2,270	2,398
14			6,252	4,660	3,820	2,810	4,030	1,564	2,076	730	2,204	3,272
15			7,430	4,240	3,612	3,404	3,612	1,476	2,270	3,744	2,204	2,546
16			7,880	4,030	3,272	3,206	3,140	1,396	2,332	4,590	2,204	2,546
17			8,030	3,960	3,008	3,272	2,876	1,308	2,270	4,240	1,948	4,590
18			9,258	4,240	2,678	3,008	2,810	1,040	2,142	4,100	2,076	4,730
19			12,220	4,660	2,546	2,810	2,678	1,372	1,948	3,744	2,010	4,800
20			15,556	4,940	2,546	2,678	2,398	2,204	1,874	3,404	2,010	5,010
21			16,998	4,940	2,480	2,480	2,142	2,142	1,820	3,206	2,010	4,730
22			18,600	4,870	2,546	2,204	2,270	1,884	1,614	2,876	1,948	5,230
23			20,100	5,010	2,744	2,014	2,142	2,014	1,846	2,810	2,014	5,230
24			20,500	5,522	2,744	2,014	2,076	2,014	1,692	2,810	1,948	5,010
25			22,100	5,960	2,942	2,142	2,142	1,884	1,604	2,678	2,142	4,940
26			23,800	5,960	3,272	1,948	2,480	2,142	1,614	2,480	2,142	4,660
27			25,600	6,106	3,404	2,014	2,810	2,076	1,618	2,142	2,076	6,536
28			26,480	5,376	3,348	1,742	2,612	2,076	1,564	2,398	1,948	3,348
29			25,300	4,940	3,206	1,860	3,140	1,948	1,362	2,270	2,142	2,876
30			23,200	4,520	3,074	2,204	3,074	2,014	1,564	2,204	2,076	3,820
31			20,700		2,876		3,140	2,270		2,204		2,678
Mean			15,963	6,827	3,209	2,386	4,507	1,864	1,924	2,305	2,073	3,168

Mean daily discharge, in second-feet, of Grand River at Fulton street, Grand Rapids, Mich.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2,612	1,948	6,471	8,411	3,470	.....	3,820	4,380	2,942	5,150	3,140	3,401
2	2,546	1,692	7,053	9,027	3,196	2,612	4,380	4,176	2,612	5,150	.....	3,404
3	2,942	2,076	7,203	9,258	3,196	2,678	10,179	.....	2,810	5,010	2,942	3,836
4	2,744	2,014	7,353	9,027	3,348	2,810	12,130	3,820	2,612	4,800	3,008	4,520
5	2,612	2,076	6,980	8,488	4,100	3,008	12,760	3,612	2,270	.....	3,348	5,080
6	2,810	2,142	6,325	7,957	4,586	2,810	.....	3,206	2,332	.....	4,730	5,522
7	2,398	2,142	5,376	7,430	6,836	3,008	12,940	3,140	.....	3,612	5,738	.....
8	2,204	2,014	5,010	7,053	8,488	.....	12,940	2,942	2,612	3,612	6,544	4,576
9	2,204	1,794	4,730	6,544	8,950	3,074	13,260	2,678	2,744	3,668	.....	4,036
10	2,270	2,142	4,240	6,106	9,566	3,612	12,310	.....	2,480	3,612	6,179	3,820
11	2,332	2,014	4,176	5,668	9,335	3,744	10,680	2,480	2,678	3,404	5,738	3,820
12	2,204	1,846	5,376	5,300	8,873	3,612	9,104	2,398	2,546	.....	5,446	3,536
13	2,480	1,948	9,770	4,730	8,180	3,404	.....	2,398	2,810	4,456	5,080	3,480
14	2,270	1,820	10,600	4,456	7,657	3,480	7,053	2,204	.....	4,660	4,940	.....
15	2,270	1,794	10,932	4,240	7,053	.....	6,252	2,076	2,810	4,800	5,230	3,348
16	2,042	1,524	11,098	3,820	6,544	4,520	5,738	2,076	2,876	4,520	.....	3,612
17	2,270	2,014	10,600	3,536	5,960	4,660	5,230	.....	2,810	4,176	5,230	3,820
18	1,884	1,742	9,770	3,404	.....	4,520	4,940	1,948	2,678	3,820	5,230	3,896
19	1,780	1,820	9,412	3,216	5,814	4,240	4,940	2,076	2,546	.....	5,080	3,960
20	2,014	1,628	7,880	3,008	5,814	4,100	.....	2,142	2,546	3,536	4,940	4,316
21	1,666	1,628	7,280	2,876	5,668	3,960	5,738	2,076	.....	3,348	4,870	.....
22	1,628	1,628	6,836	2,810	5,592	.....	6,179	2,076	2,546	3,272	4,730	6,980
23	2,142	1,564	6,252	2,678	5,446	3,404	6,617	2,142	2,398	3,348	.....	7,430
24	1,756	1,884	5,814	2,546	5,376	3,216	6,680	.....	2,142	3,272	4,520	6,980
25	2,142	1,628	5,300	2,480	.....	3,216	6,325	2,204	2,332	3,272	4,316	.....
26	1,538	1,948	5,010	2,678	4,590	3,074	6,252	2,142	2,612	.....	3,960	6,617
27	2,546	2,398	4,660	3,074	4,100	3,008	.....	2,398	3,612	3,348	.....	5,884
28	2,744	4,176	4,590	3,668	3,612	2,744	5,592	2,480	.....	3,348	3,480	.....
29	2,332	.....	4,870	3,886	3,196	.....	5,300	2,480	4,520	3,348	3,404	5,300
30	2,204	.....	5,738	3,820	3,206	3,140	5,080	2,480	4,596	3,348	.....	5,446
31	2,014	.....	6,980	.....	2,612	.....	4,730	.....	.....	3,206	.....	5,446
Mean	2,245	1,965	6,893	5,039	5,667	3,426	7,709	2,624	2,787	3,888	4,659	4,698

Estimated monthly discharge of Grand River at Grand Rapids, Mich.

[Drainage area, 4,900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
March	26,480	4,240	15,963	3.25	3.75
April	18,255	3,960	6,827	1.39	1.55
May	4,240	2,480	3,209	.66	.76
June	3,404	1,742	2,386	.49	.55
July	11,950	1,666	4,507	.92	1.06
August	2,810	1,040	1,864	.38	.44
September	3,008	1,362	1,924	.39	.44
October	4,590	730	2,305	.47	.54
November	2,948	1,756	2,073	.42	.47
December	5,230	1,372	3,168	.65	.75
The year	26,480	730			10.33
1902.					
January	2,942	1,628	2,245	.46	.53
February	4,176	1,524	1,965	.40	.42
March	11,098	4,176	6,893	1.41	1.63
April	9,258	2,480	5,039	1.03	1.15
May	9,566	3,196	5,667	1.15	1.33
June	4,660	2,612	3,426	.70	.78
July	13,260	3,820	7,709	1.57	1.81
August	4,380	1,948	2,624	.53	.61
September	4,596	2,142	2,787	.57	.63
October	5,150	3,272	3,888	.79	.91
November	6,544	3,008	4,659	.95	1.05
December	7,430	3,348	4,698	.96	1.10
The year	13,260	1,524	4,300	.88	11.95

CROCKERY CKEEK AT SLOCUMS GROVE, MICHIGAN.

Crockery Creek is a tributary of Grand River, Michigan. It rises in T. 11 N., R. 13 W., and flows southerly through central Muskegon County, entering Grand River 10 miles from Lake Michigan. A gaging station was established at the Toledo, Saginaw and Muskegon (Pere Marquette system) Railroad bridge at Slocum Station, on the north branch of the stream, October 1, 1902. The gaging station was

established in cooperation with Charles W. Garfield, president of the State forestry commission, and Walter C. Winchester, of the Foster-Winchester Lumber Company, of Grand Rapids. The gage scale is attached vertically to the bridge piling on the left-hand end, downstream side of bridge. A reading was taken once each day, as a rule, during a part of November and December, 1902, by Ray M. Beardsley. December 6, 1902, the record was discontinued for the winter, owing to obstruction of the stream channel by ice.

The bench mark is the top of the timber pile coping over the gage: elevation, 100 feet. The elevation of the zero of the gage is 82.43 feet.

The gage is located about 1,000 feet below a dam forming a log pond for the Foster-Winchester sawmill. The pond level is regulated by flashboards, and the flow past the gage varies accordingly. A discharge measurement by W. V. Savicki, October 4, 1902, gage height 1.4, gave a discharge of 97.7 second-feet.

The drainage area, as nearly as may be determined in the absence of topographic maps, is as follows:[a]

Crockery Creek drainage area.

Location.	Square miles.	Increment, square miles.
Above Slocum	45	.....
Above mouth	174	129

The length of the stream above the gaging station is about 10 miles. Beginning at Slocum, extending upstream and covering an aggregate area of between 5,000 and 6,000 acres, is a hard-wood and hemlock forest which is now being lumbered. The remainder of the basin is mostly cleared and much is under cultivation. The soil is sandy, and after the timber is cut the hitherto forest-covered area rapidly grows up to brush and shrubs, so that the soil is shaded and protected much as in the original forest.

Aside from the lumbering dam at Slocum, there are no lakes or dams within the basin above the point of gaging.

[a] From John F. Nellist, road map of Lower Michigan.

Daily gage height, in feet, of Crockery Creek at Slocums Grove, Mich.

Date.	Gage height.	Date.	Gage height.
1902.	*Feet.*	1902.	*Feet.*
October 31	1.3	November 13	0.7
November 1	1.2	November 14	.8
November 2	1.1	November 15	.8
November 3	1.1	November 16	1.1
November 4	1.0	November 17	1.1
November 5	2.4	November 18	1.2
November 6	2.3	November 19	1.1
November 7	1.5	November 20	1.0
November 8	.....	November 21	1.2
November 9	1.3	November 22	1.1
November 10	1.4	December 4	1.2
November 11	1.3	December 5	1.3
November 12	.8	December 6	1.3

GRAND RIVER AT NORTH LANSING, MICH.

The gaging station, which is located at Seymour street bridge, North Lansing, was established by H. K. Vedder, C. E., March 2, 1901. The gage is attached vertically to the downstream end of the central pier of the bridge, and is read twice each day by Thomas Costigan. The bridge has two spans of 92 feet each. The bed is of earth and the current is smooth and uniform.

About November 8, 1901, a low submerged dam was constructed a short distance downstream from the gaging station to furnish water supply to the adjacent factory of the Michigan Beet Sugar Company during its season of operation. In this factory the beets are transferred from the storage bins to the various operations by floating in troughs of water. The diversion is small, compared with the flow of the stream. In order to determine the effect of the submerged dam on the gage readings, a second gage has been established a short distance downstream and comparative readings have been taken, from which the gage readings prior to the construction of the dam have been corrected to conform to the later readings. A rating table has been prepared by means of discharge measurements made during 1902 and 1903.

The gaging station is located a short distance below the North Lansing dam and is but little affected by ice. Water-power improvements and extensions are contemplated on this stream at North Lansing, and at Delta, 8 miles below.

Discharge measurements of Grand River at Seymour street, North Lansing, Mich.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 22	H. K. Vedder	4.36	1,386
August 27	R. E. Horton	[a] 2.50	[a] 382
August 30	do	[a] 2.46	337
September 30	W. M. Gregory	1.80	299
October 6	W. V. Savicki	4.58	1,548
October 8	do	5.40	1,994
October 10	do	4.27	1,290

[a] Gage height raised by temporary extension of submerged dam below.

Mean daily gage height, in feet, of Grand River at North Lansing, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.36	1.54	5.66	6.20	3.30	2.75	5.23	4.15	2.20	5.68	2.47	2.91
2	3.21	1.60	5.60	6.09	3.30	2.90	5.60	4.40	2.45	5.33	2.75	2.99
3	3.02	2.10	5.20	5.71	3.15	2.95	6.54	4.20	2.30	4.83	2.69	3.66
4	2.85	2.28	4.80	5.50	3.34	3.08	7.65	3.95	2.35	4.33	2.63	4.40
5	2.55	2.35	4.51	5.30	3.52	2.84	9.73	3.69	1.83	4.00	2.67	4.35
6	2.75	2.40	4.19	4.98	3.90	2.65	9.50	3.56	2.20	4.34	3.35	4.00
7	3.05	2.90	3.89	4.73	5.60	3.50	8.23	3.39	1.90	4.68	3.82	3.86
8	3.12	2.95	3.94	4.49	6.69	4.36	6.84	3.37	2.05	4.52	3.85	3.60
9	2.86	1.80	3.84	4.35	6.36	4.72	6.20	3.25	2.05	4.30	3.63	3.13
10	3.14	2.43	3.92	4.20	5.70	4.40	5.56	3.29	2.10	4.00	3.42	2.96
11	2.93	2.56	4.02	4.00	5.43	4.04	5.04	3.22	2.15	3.68	3.30	3.02
12	2.50	2.45	4.86	3.90	4.94	3.68	4.63	3.06	2.08	3.70	3.28	3.12
13	2.65	2.31	6.05	3.76	4.62	3.75	4.43	3.13	2.15	3.49	3.08	2.74
14	3.05	2.34	6.08	3.60	4.49	4.63	4.26	3.00	2.09	3.48	3.25	2.58
15	3.05	2.80	5.74	3.50	4.45	5.03	4.08	3.00	2.13	3.43	3.30	2.77
16	3.00	1.40	5.29	3.44	4.16	5.05	3.91	3.05	2.13	3.39	3.33	2.78
17	2.93	2.60	5.49	3.25	3.74	4.99	3.68	2.90	1.85	3.27	3.56	3.00
18	3.33	2.50	4.95	3.20	3.90	4.91	3.79	2.75	1.95	3.18	3.90	3.20
19	2.65	2.35	4.59	3.13	4.43	4.36	4.28	2.73	1.89	3.31	3.78	3.19
20	2.79	2.20	4.47	3.27	4.84	4.30	5.50	2.72	1.78	3.28	3.66	3.23
21	2.85	2.73	4.25	3.00	4.85	3.91	6.08	2.48	2.02	3.24	3.40	4.00
22	2.74	2.40	4.11	3.00	4.69	3.75	6.24	2.28	1.85	3.27	3.35	4.80
23	2.75	1.25	4.17	2.70	4.29	3.48	5.90	2.23	2.03	3.04	3.31	5.18
24	2.58	1.90	3.95	2.55	4.00	3.15	5.46	2.51	2.33	2.89	3.13	4.76
25	2.74	2.40	3.87	2.76	3.82	3.24	5.03	2.59	4.43	2.77	3.01	3.70
26	2.18	2.28	3.72	4.10	3.72	3.00	4.65	2.39	5.13	2.81	2.85	3.37
27	2.75	4.04	3.55	4.65	3.41	2.90	4.65	2.26	4.84	2.98	2.89	3.45
28	2.90	5.00	3.49	4.25	3.12	2.73	4.30	2.15	5.66	3.16	2.79	3.50
29	2.78	.....	4.38	3.88	3.14	3.15	4.16	2.28	5.79	3.00	2.81	3.63
30	4.34	.....	5.08	3.60	3.05	4.10	3.89	2.13	5.94	2.87	2.91	3.60
31	2.18	.....	5.60	.....	2.88	.....	3.69	1.95	.....	2.63	.....	3.37

Mean daily discharge, in second-feet, of Grand River at North Lansing, Mich.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	.....	.....	.....	2,22	653	488	577	864	577	440	360	456
2	.....	.....	.....	1,998	653	539	577	732	577	332	360	424
3	.....	.....	456	1,874	577	488	520	710	754	318	206	424
4	.....	.....	558	1,630	520	392	504	539	886	332	304	424
5	.....	.....	634	1,510	504	360	1,750	930	710	276	332	392
6	.....	.....	710	1,450	456	346	3,262	732	732	290	332	424
7	.....	.....	672	1,480	456	332	2,801	615	672	248	346	392
8	.....	.....	615	1,396	472	304	2,258	1.080	615	248	304	392
9	.....	.....	615	1,342	691	290	1,750	672	577	234	276	440
10	.....	.....	864	1,261	1,005	290	1,396	596	472	248	178	558
11	.....	.....	1,261	1,080	1,080	346	1,055	577	488	304	376	864
12	.....	.....	1,630	1,005	1,055	262	842	776	634	248	440	908
13	.....	.....	1,812	980	456	446	691	710	798	1,261	456	1,005
14	.....	.....	2,258	930	691	536	634	691	653	1,843	596	1,261
15	.....	.....	842	886	558	440	634	577	346	1,812	596	1,423
16	.....	.....	2,323	820	504	488	615	615	577	1,660	634	1,570
17	.....	.....	2,649	842	440	440	488	488	504	1,369	524	1,570
18	.....	.....	3,446	930	376	318	539	504	456	1,030	577	1,570
19	.....	.....	6,120	1,180	424	392	615	691	332	908	596	1,480
20	.....	.....	8,792	1,180	424	332	596	615	424	776	558	1,315
21	.....	.....	9,035	1,130	360	304	539	577	488	710	634	1,130
22	.....	.....	7,577	1,396	392	304	577	634	456	634	539	930
23	.....	.....	6,387	1,600	392	332	634	710	520	615	440	754
24	.....	.....	7,010	1,812	504	290	583	732	472	504	392	615
25	.....	.....	5,898	1,690	710	304	456	791	392	577	348	504
26	.....	.....	6,298	1,510	776	472	424	754	440	488	376	577
27	.....	.....	5,676	1,261	776	691	798	732	424	392	634	520
28	.....	.....	4,362	1,055	710	710	886	864	440	408	440	615
29	.....	.....	3,584	908	672	672	886	842	276	376	539	710
30	.....	.....	2,924	798	520	615	886	930	472	408	360	776
31	.....	.....	2,538	.....	691	.....	820	886	.....	346	.....	798

Mean daily discharge, in second-feet, of Grand River at North Lansing, Mich.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	864	234	2,159	2,538	842	612	1,905	1,261	248	2,192	504	672
2	798	248	2,126	2,464	842	672	2,126	1,396	318	1,967	615	710
3	710	392	1,874	2,192	776	694	2,801	1,288	276	1,660	596	1,005
4	653	456	1,630	2,060	864	754	3,780	1,155	290	1,369	577	1,396
5	539	472	1,450	1,936	930	653	6,565	1,030	150	1,180	577	1,369
6	615	488	1,288	1,750	1,130	577	6,120	955	248	1,369	864	1,180
7	732	672	1,130	1,600	2,126	930	4,420	886	164	1,570	1,080	1,105
8	754	691	1,155	1,450	2,924	1,369	3,047	864	206	1,450	1,105	980
9	653	304	1,105	1,369	2,649	1,570	2,538	820	206	1,342	1,005	776
10	776	504	1,130	1,288	2,192	1,396	2,091	842	220	1,180	886	694
11	672	539	1,180	1,180	2,029	1,207	1,781	798	234	1,030	842	710
12	520	504	1,660	1,130	1,720	1,030	1,540	732	220	1,030	842	754
13	574	456	2,427	1,055	1,510	1,055	1,423	776	234	930	754	615
14	732	472	2,464	980	1,450	1,510	1,315	710	220	930	820	558
15	732	634	2,225	930	1,423	1,781	1,234	710	234	908	842	615
16	710	192	1,936	908	1,261	1,781	1,130	732	408	886	886	634
17	791	558	2,060	820	1,055	1,750	1,030	672	318	842	955	710
18	864	520	1,720	798	1,130	1,690	1,080	615	346	798	1,130	798
19	574	472	1,510	776	1,423	1,369	1,342	615	332	842	1,080	798
20	634	424	1,423	820	1,657	1,342	2,060	596	304	842	1,005	820
21	653	615	1,315	710	1,660	1,130	2,464	520	360	820	886	440
22	615	488	1,234	710	1,570	1,055	2,575	456	318	842	864	732
23	615	150	1,261	596	1,342	930	2,324	440	376	732	842	908
24	558	332	1,155	539	1,180	776	2,029	520	472	672	776	710
25	615	488	1,105	615	1,080	820	1,781	558	1,423	615	710	346
26	424	456	1,030	1,234	1,030	710	1,540	488	1,843	634	653	248
27	615	1,207	955	1,540	886	672	1,540	440	1,657	710	672	276
28	672	1,750	930	1,315	754	612	1,342	234	2,159	776	634	290
29	634	.....	1,396	1,130	776	776	1,261	276	2,258	710	634	1,005
30	1,369	.....	1,812	980	732	1,234	1,130	234	2,357	672	672	980
31	424	.....	2,126	.....	672	.....	1,030	178	.....	577	.....	864

Estimated monthly discharge of Grand River at North Lansing, Mich.

[Drainage area, 1,230 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
March	9,035	456	3,363	2.73	3.15
April	2,225	798	1,305	1.06	1.18
May	1,055	360	596	.48	.55
June	710	262	417	.34	.38
July	3,262	424	954	.78	.90
August	1,080	488	715	.58	.67
September	886	276	538	.44	.49
October	1,843	234	633	.51	.59
November	634	178	435	.35	.39
December	1,570	392	813	.66	.76
1902.					
January	1,369	424	680	.55	.63
February	1,750	150	525	.43	.45
March	2,464	930	1,547	1.26	1.45
April	2,538	539	1,247	1.02	1.14
May	2,924	672	1,342	1.09	1.26
June	1,781	577	1,081	.88	.98
July	6,565	1,030	2,204	1.78	2.05
August	1,396	178	703	.57	.66
September	2,357	150	613	.50	.56
October	2,192	577	1,034	.84	.97
November	1,130	504	810	.66	.73
December	1,396	248	764	.62	.71
The year	6,565	150	1,046	.85	11.59

RED CEDAR RIVER AT AGRICULTURAL COLLEGE, MICH.

This gaging station was established August 30, 1902. The gage is located at the highway bridge just below the Agricultural College grounds. The bridge has a single span of 75 feet between abutments. The bed is of sand and gravel, fairly smooth and permanent. The channel is straight for a distance of about 400 feet downstream from the gage. A short distance upstream is a low dam forming an ice pond, below which the stream does not ordinarily freeze over. In this stretch of the river is the railroad bridge of the college spur of the

Pere Marquette Railroad, from which gagings are made at high water or when the stream is frozen across at the gaging station. Near this bridge low-water measurements are also made by wading. The gage is of the usual wire type, and is attached to the downstream guard rail of the bridge. The upstream corner of the right-hand wing wall of the bridge abutment is used as a bench mark, with an arbitrary elevation of 100 feet. The elevation of the datum plane of the gage is 85.45 feet. The gage is read twice each day by Clifford Walters.

The gaging station is situated about 4 miles from the mouth of the stream. Sycamore Creek, an important tributary, enters in this section. The drainage area above the gaging station is 358 square miles, and from the gaging station to the mouth of the stream 114 square miles, making the total above Grand River 472 square miles.

Discharge measurements of Red Cedar River at Agricultural College, Mich.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 13	H. K. Vedder		796
August 28	R. E. Horton	1.48	7
August 30	do	1.50	11
September 19	W. M. Gregory	1.78	37
October 10	W. V. Savicki	5.66	535

Mean daily gage height, in feet, of Red Cedar River at Agricultural College, Mich.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.					1902.					
1	1.70	6.60	3.15	3.42	17		1.70	3.53	4.10	3.57
2	1.75	6.30	3.07	3.30	18		1.85	3.37	4.63	3.70
3	1.90	5.67	3.08	4.17	19		1.97	3.40	4.55	3.70
4	2.05	5.07	3.05	5.30	20		1.77	3.50	4.22	3.82
5	1.95	4.63	3.00	5.07	21		1.67	3.35	4.00	4.82
6	1.80	5.30	4.07	4.55	22		1.55	3.27	3.77	6.35
7	1.93	5.90	4.92	4.13	23		2.12	3.17	3.67	6.68
8	1.80	5.50	4.50	3.90	24		2.75	3.10	3.53	6.15
9	1.85	5.35	4.28	3.88	25		4.37	3.08	3.35	6.15
10	1.82	4.55	4.05	3.72	26		5.30	3.10	3.27	6.17
11	2.02	4.12	3.80	3.62	27		5.25	3.45	3.23	6.10
12	1.97	3.77	3.70	3.52	28		6.02	3.75	3.22	5.85
13	2.12	3.77		3.87	29		6.82	3.57	3.28	5.35
14	1.48	3.73		3.47	30		6.95	3.43	3.35	5.05
15	1.67	3.65	3.72	3.20	31	1.62		3.30		4.42
16	1.65	3.57	3.78	3.33						

MUSKEGON RIVER DRAINAGE BASIN.

The drainage basin of this stream lies immediately north of that of Grand River. Originally it was covered with pine timber, but now it is almost entirely cleared. Much of the soil is sand and gravel, unfit for profitable cultivation. Large stump-covered areas form a conspicuous feature of the topography.

In the upper portion of the basin there is a total lake area of about 110 square miles.

MUSKEGON RIVER AT NEWAYGO, MICH.

A gaging station was established at the dam of the Newaygo Portland Cement Company, April, 1901. The crest gage is attached to a crib 50 feet upstream from the center of the dam. The dam contains a fishway 17 feet in length, 4 Taintor flood gates of 20 feet each, a spillway 20 feet in length, a logway 21.5 feet in length, and a main overflow 120 feet in length. A record is kept of the depth on the crest gage and on a tailrace gage having its datum 14 feet lower, and of the opening and closing of the logway and flood gates. The hours of running of the three sets of 35-inch horizontal Samson turbines in the adjacent power plant, and the gate opening at which they are operated, are also recorded.

A survey of the dam was made and tests of the turbine discharge were taken by current meter August 29, 1902. The daily discharge has not been calculated from the record. The gaging station is maintained through the cooperation of the Newaygo Portland Cement Company, and the record is kept by E. N. Hanlon, C. E.

RIFLE RIVER DRAINAGE BASIN.

Rifle River rises in the vicinity of Rose City, northern Ogemaw County, flows southward to the northwest corner of T. 19 N., R. 4 W., turns easterly, and then gradually to the southeast, finally entering Saginaw Bay. The basin is heavily overlain with glacial deposits—sand, overwash gravel, and till—sand predominating. There are two old lumber dams in the basin, and a water-power dam at Omer. There are numerous small glacial lakes, but no controlled storage, and a very small percentage of natural water surface in the drainage basin. The basin is narrow and elongated, having a width of about 3 miles at the mouth. Ramifying tributaries in the headwaters give the stream a relatively large volume at the entrance of West Branch, in T. 21 N., R. 3 E. Just below the junction of the branches, at the south line of section 9 of this township, the stream is at an elevation of 771 feet, or 176 feet above Lake Huron. The distance from Omer, measured along the winding stream, is 23 miles; the average fall 7.7 feet per mile. At this place the stream flows over sandstone ledges.

An abandoned lumber dam gives 8 feet fall. It is stated that a head of 15 feet is obtainable. The drainage area is 217 square miles.

Much of the fall from this point to Omer is concentrated in rapids over sandstone shale. The fall in the first 3 miles is 51 feet, the lower portion being known as Isle Rapids, covering a length of three-fourths of a mile. In the next succeeding 2 miles the stream falls from an elevation of 720 feet to an elevation of 693 feet, partly over arenaceous limestone. For 10 miles below this point the fall is slight. The stream has in places bold clay banks 40 feet in height. At the foot of this stretch an old lumber dam near Melita gives a head of 15 feet. Rapids occur below this dam.

RIFLE RIVER AT OMER, MICH.

At Omer the stream falls from an elevation of 608 to 595 feet over a dam affording power for a grist and saw mill. A lumbermen's canal, long since abandoned, was constructed from the northwest corner of sec. 25, T. 19 N., R. 5 E., to Wigwam Bay, a distance of 15 miles, giving 15 feet fall, by cutting off a stretch of about 4 miles of the river running parallel to the bay.

The drainage area at Omer is 364 square miles, and at the mouth of the stream 385 square miles. The gaging station is at the Detroit and Mackinaw Railroad bridge, one-half mile below the dam in Omer village. A weight and wire gage with a boxed scale graduated to feet and tenths is attached to the downstream guard rail of the bridge. The datum is referred to the right-hand downstream corner of the left-hand bridge abutment. The elevation of the bench mark is 100 feet; of the zero of the gage, 84.25 feet.

The bridge has a single span of 109 feet. The bed is of sand and fine drift. Bends occur a short distance above and below the gaging bridge, and the current passes underneath the bridge at a slight angle in times of low water. The gaging station was established September 1, 1902, and the river stage is observed twice each day by M. D. Murchison. The following table contains the results of discharge measurements which were made during 1902:

Discharge measurements of Rifle River at Omer, Mich.

Date.	Hydrograph	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
August 15	Horton and Gregory	4.96	265
Do	do	4.87	213
September 12	W. M. Gregory	4.85	218
September 13	do	5.28	284
October 5	W. V. Savicki	5.50	289
Do	do	5.46	260

Mean daily gage height, in feet, of Rifle River at Omer, Mich.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1	4.68	5.53	5.65	6.25	17	5.13	5.53	6.90	6.18
2	5.03	5.33	5.48	5.53	18	5.00	5.25	6.75	6.03
3	5.10	5.28	5.75	5.95	19	4.95	5.25	6.38	6.00
4	4.90	5.40	5.50	6.13	20	5.08	5.55	6.28	5.98
5	4.63	5.10	5.68	6.28	21	4.88	5.20	6.05	6.00
6	5.28	5.33	6.80	5.90	22	5.15	5.20	5.93	6.38
7	4.93	5.03	6.80	5.63	23	5.33	5.63	6.05	7.03
8	4.88	5.25	6.13	5.55	24	5.30	5.50	5.90	6.88
9	4.85	5.15	6.10	6.10	25	5.20	5.43	5.75	6.08
10	4.98	5.20	5.85	5.68	26	5.03	5.65	5.70	6.33
11	4.93	5.03	6.05	6.33	27	5.33	6.70	5.53	6.13
12	5.20	4.98	5.85	6.03	28	4.98	6.63	5.65	6.40
13	4.88	5.90	6.25	6.30	29	5.15	6.08	5.83	6.78
14	4.88	5.93	6.25	6.33	30	5.43	5.93	5.88	6.95
15	4.93	5.80	6.30	6.05	31	.....	5.78	.....	6.93
16	4.98	5.63	7.30	5.90					

AU SABLE RIVER DRAINAGE BASIN.

Au Sable River rises in southern Otsego County, flows south to Grayling, thence east to the west line of Alcona County, from which point it follows a tortuous course in a general southeasterly direction to its outlet in Lake Huron at Oscoda. Its drainage basin embraces a region at one time noted for the abundance of white pine. The area is now almost entirely cleared of its valuable native timber and contains a large extent of what are termed "jack-pine lands"—sandy plains covered with scrub conifers. There are also areas of diversified soils, pink clay, loam, and gravel. The basin is underlain by Coldwater shales. Rock outcrops are very rare, the stream bed being usually clay or sand.

The basin contains numerous small lakes, wet sand areas, and undrained hollows, the topographic features being mainly the work of the retreating ice of the glacial epoch. At the junction of the north and south branches, in sec. 1, T. 26 N., R. 1 W., the stream is at an elevation of about 1,100 feet above sea level, or 520 feet above Lake Huron. This point is about 90 miles from the mouth of the river, measured along the stream channel.

At Bamfield, about 40 miles from the outlet, following the river, the elevation is about 850 feet above sea level. From this point to the mouth of the stream numerous excellent sites for water-power development occur. These water powers are favored by a stream bed of firm clay, the river being flanked in many places with high terraced clay bluffs, rising often 60 to 100 feet above the river. In some places the upper half or two-thirds of the bluff is sand, the lower portion being

clay. At the clay horizon numerous springs appear. The precipitation over the drainage area varies from 25 or 30 inches a year in the vicinity of the source to 35 or 40 inches at the mouth of the stream. The tributaries are not important, nearly all the rainfall being directly absorbed by the porous sand areas.

It is stated that the fall between Flat Rock, near the south line of sec. 33, T. 26 N., R. 5 E., and Bamfield is about 20 feet. From Bamfield to sec. 16, T. 24 N., R. 16 W., occurs a drop of 200 feet, 50 or 55 feet of which is concentrated within a series of rapids lying in Iosco County, covering a total distance of 4 miles.

AU SABLE RIVER AT BAMFIELD, MICH.

A gaging station was established at the highway bridge at Bamfield August 27, 1902, and gage readings have been taken since that date each morning and evening by William H. Bamfield. The gage is a vertical scale graduated to feet and tenths, attached to the left-hand downstream side of the left pier supporting the main bridge span. The stream channel is straight for a distance of 800 feet or more downstream, and in this distance slight rifts occur. A bend occurs about 500 feet upstream from the gage. The bed is of sand and gravel, with a relatively smooth deep current. The banks are low and are skirted on the right by a flood plain, which is, however, seldom overflowed. Beyond the flood plain on the right, and close to the river on the left, are high gravel banks. The bridge has a main Pratt truss span of 92 feet, with auxiliary flood channels at both ends. Wire spikes, driven into the upstream end of the left-hand pier, serve as a temporary bench mark. The elevation of the bench mark is 100 feet; of the zero of the gage, 92 feet.

The stream freezes over in winter and special discharge measurements are required to determine the flow from gage readings for that season.

During 1902 the following discharge measurements were made by Messrs. Horton, Gregory, and Savicki:

August 14: Discharge, 1,133 second-feet.
August 26: Gage height, 0.82 foot; discharge 1,026 second-feet.
September 17: Gage height, 0.80 foot; discharge, 998 second-feet.
October 7: Gage height, 0.72 foot; discharge, 981 second-feet.

In addition to the above, a gaging of Bamfield Creek, a small stream entering from the right just below the gaging station, was made by W. V. Savicki October 7, 1902, showing a discharge of 8.3 second-feet. The drainage area above the junction of the two branches of Au Sable River is 1,005 square miles; above the gaging station at Bamfield, 1,425 square miles, and above its mouth at Oscoda, 1,932 square miles.

Mean daily gage height, in feet, of Au Sable River at Bamfield, Mich.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1	.....	0.80	1.00	1.00	1.50	17	.....	0.80	0.90	1.90	1.40
2	.....	.80	.90	1.00	1.50	18	.....	.80	.90	1.70	1.40
3	.....	.80	.80	.90	1.50	19	.....	.80	.80	1.60	1.40
4	.....	.85	.80	.90	1.50	20	.....	.80	.80	1.60	1.30
5	.....	.80	.80	1.10	1.50	21	.....	.80	.80	1.50	1.30
6	.....	.80	.80	2.10	1.50	22	.....	.80	.80	1.50	1.30
7	.....	.80	.80	2.00	1.70	23	.....	.80	.90	1.40	1.30
8	.....	.80	.75	1.80	1.70	24	.....	.80	1.00	1.40	1.30
9	.....	.80	.80	1.55	1.70	25	.....	.80	1.00	1.40	1.30
10	.....	.80	.80	1.55	1.70	26	.....	.80	1.05	1.40	1.25
11	.....	.80	.80	1.50	1.50	27	0.85	.90	1.70	1.40	1.20
12	.....	.80	.80	1.65	1.50	28	.80	.90	1.30	1.30	1.20
13	.....	.80	.95	1.70	1.50	29	.80	.80	1.25	1.30	1.20
14	.....	.80	.90	1.80	1.50	30	.80	1.05	1.25	1.50	1.20
15	.....	.80	.90	1.80	1.40	31	.80	.....	1.10	.....	1.20
16	.....	.80	.80	1.80	1.40						

THUNDER BAY RIVER DRAINAGE BASIN.

Thunder Bay River is joined by two large branches 8 and 10 miles above its mouth, respectively. These branches, as well as the main stream, are further subdivided at short distances upstream, so that the river is of relatively small magnitude, except for a few miles near its mouth. The Traverse shales outcrop in this part of the stream, and it is in passing over this rock ledge that the most rapid fall occurs. The drainage area was formerly heavily timbered with Michigan pine. Most of the pine has been cut, but a large amount of small conifers, hard woods, white birch, and cedar remains, so that the basin may be considered a forested rather than a cleared area.

The drainage basin contains 30 lakes, with an average area of about 1 square mile. In addition to these is Hubbard Lake, which has a water surface of 13.4 square miles. A timber dam at the foot of the latter lake produces a storage depth of 5 feet, with an aggregate storage capacity of 1,867,500,000 cubic feet, equivalent to a flow of 68 second-feet for thirty days. A similar dam at the foot of Beaver Lake gives a storage depth of 6 feet. The water from Beaver Lake is used chiefly for driving logs.

THUNDER BAY RIVER NEAR ALPENA, MICH.

A gaging station was established at the dam of the Fletcher Paper Company, 4 miles above Alpena, April 4, 1901. The record includes two readings each day of the depth on the crest gage, located 75 feet upstream from the headgates, opposite the left-hand end of the dam.

The dam is of timber, practically water-tight, and is usually surmounted by flashboards. It contains, in addition to three spillway sections of lengths 90, 105, and 181.5 feet, respectively, a log slide 40 feet in width.

The crest of the dam was originally level, but settlement of the middle section has made it necessary to subdivide the spillways into several short sections, each assumed level at its average elevation, for purposes of calculation.

The discharge over the main dam has been calculated by the weir formula, using coefficients derived from Cornell University Experiment No. 13 for a dam of similar cross section. Discharge over flashboard sections has been calculated by means of the Francis formula.

There is also a subsidiary log way and a headrace overflow, the latter 3 feet in width, the flow through which has been calculated by suitable formulas.

The adjoining pulp and paper mill has 14 pairs of 26-inch Trump model turbines, arranged in three groups, each containing four turbines on horizontal shafts, with one double horizontal turbine. The daily run of the turbines and the working head on the wheels, which is determined from readings of the crest and tailrace gages, is also recorded.

A survey of the dam was made August 13, 1902. The accompanying tables show the estimated daily discharge and monthly run-off of the stream at this station. A measurement of the discharge at the highway bridge, 2 miles downstream, August 13, 1902, showed the flow to be 1,537 second-feet, with water wheels running. The mean flow for the day was much less.

Mean daily discharge, in second-feet, of Thunder Bay River near Alpena, Mich.

[Drainage area, 1,260 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1				1,968	2,072	1,237	993	1,262	2,060	576	689	809
2				2,133	1,898	1,038	639	1,159	3,265	616	704	804
3				2,356	2,072	1,587	774	964	554	612	30	564
4				3,356	2,397	1,322	655	444	548	641	860	377
5				3,332	2,008	1,267	844	596	543	610	770	395
6				3,600	2,013	1,423	910	596	456	60	786	509
7				3,350	1,487	1,296	481	634	373	616	864	565
8				3,765	1,380	1,106	773	610	582	603	752	446
9				3,443	1,616	509	902	505	703	625	641	624
10				3,550	1,616	903	765	503	317	587	406	652
11				3,817	1,254	973	718	20	373	604	806	591
12				3,571	1,447	600	687	561	550	116	754	643
13				3,545	2,095	531	548	561	702	97	891	670
14				3,572	1,532	451	20	507	574	946	1,000	646
15				3,219	1,421	522	657	508	276	1,670	796	947
16				3,090	968	673	559	526	879	1,400	653	608
17				2,685	815	757	587	354	888	1,365	479	608
18				3,263	701	603	483	325	898	1,181	906	595
19				3,200	590	648	453	399	643	1,662	918	583
20				2,533	750	666	483	853	649	1,301	662	506
21				3,350	630	603	349	481	639	1,246	930	490
22				3,386	582	503	455	511	88	817	773	324
23				2,988	609	20	543	635	612	819	574	522
24				1,870	730	548	519	519	535	760	474	481
25				2,403	804	461	433	164	590	729	760	20
26				2,766	560	376	483	596	624	784	725	548
27				2,301	730	405	426	736	523	180	550	544
28				3,408	967	491	310	790	475	798	496	551
29				2,900	933	429	1,025	750	38	826	629	356
30				147	837	142	1,576	1,005	589	806	750	584
31				.....	830	.....	1,841	954	.....	805	.....	675
Mean				2,962	1,236	736	673	611	684	788	700	556

Mean daily discharge, in second-feet, of Thunder Bay River near Alpena, Mich.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	558	393	720	1,126	1,664	857	839	721	a 22	347	768	747
2	534	245	627	1,280	1,451	906	582	751	20	353	513	770
3	505	410	1,026	1,127	1,233	931	517	231	21	338	799	837
4	488	410	1,070	983	1,105	999	346	787	20	350	676	792
5	499	402	882	1,082	1,603	1,869	546	510	20	150	714	752
6	528	410	896	622	1,081	1,543	559	721	20	851	892	572
7	527	410	835	1,125	1,118	1,536	663	751	20	952	1,047	20
8	519	393	766	1,113	1,149	1,186	913	747	47	440	1,159	560
9	546	251	454	1,127	1,132	983	813	772	20	561	749	550
10	549	410	823	1,111	892	979	815	231	21	41	1,100	608
11	539	410	1,126	1,127	622	698	946	932	21	21	1,088	605
12	528	410	1,326	1,081	1,125	672	448	787	22	20	1,098	733
13	527	410	1,270	623	1,125	646	20	698	432	395	1,100	739
14	527	369	2,159	1,103	1,066	1,014	721	799	432	426	1,145	20
15	539	403	3,798	1,125	1,000	454	759	792	432	615	1,455	654
16	553	251	2,368	1,047	1,014	1,123	759	792	155	517	729	546
17	565	410	2,237	1,000	1,007	1,194	759	231	176	562	1,102	482
18	439	410	1,700	884	120	830	753	745	177	682	1,102	482
19	528	410	1,668	903	593	727	740	812	177	288	1,100	482
20	527	410	1,301	621	728	564	539	794	438	1,208	1,144	463
21	521	410	954	1,094	719	562	813	806	335	766	1,086	20
22	527	393	1,143	1,021	796	20	810	811	178	618	857	473
23	535	247	590	1,031	814	617	823	808	178	621	605	482
24	490	410	1,209	1,047	1,184	529	759	231	176	665	996	316
25	483	410	1,386	1,037	1,112	439	759	870	174	615	921	71
26	496	406	990	1,041	1,667	517	759	831	171	530	828	482
27	490	420	944	622	1,838	583	20	579	504	797	906	463
28	480	500	1,086	1,664	1,702	628	988	729	352	957	858	20
29	470	.....	1,055	1,664	1,459	20	813	709	439	904	757	482
30	468	.....	602	1,665	1,314	689	759	721	315	945	485	482
31	470	.....	1,099	.....	1,021	.....	759	.....	.....	812	.....	233
Mean	514	386	1,229	1,069	1,111	810	699	689	183	559	925	483

a Mill shut down; storage pond refilling September 1 to 12.

Estimated monthly discharge of Thunder Bay River near Alpena, Mich.

[Drainage area, 1,260 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
April	3,817	147	1,882	1.49	1.66
May	2,397	582	1,490	1.18	1.36
June	1,587	20	798	.63	.71
July	1,841	20	931	.74	.85
August	1,262	20	641	.51	.58
September	3,265	38	1,654	1.31	1.46
October	1,670	97	884	.70	.81
November	1,000	30	515	.41	.46
December	809	20	414	.32	.36
1902.					
January	565	439	502	.40	.46
February	500	245	372	.29	.30
March	3,798	454	2,126	1.31	1.51
April	1,665	621	1,143	.91	1.02
May	1,838	120	979	.78	.90
June	1,869	20	944	.74	.82
July	988	20	504	.40	.46
August	932	231	582	.46	.52
September	504	20	262	.21	.24
October	1,208	20	614	.48	.55
November	1,455	485	970	.77	.86
December	837	20	428	.34	.39
The year	3,798	20	786	.59	8.03

LOW-WATER MEASUREMENTS OF STREAMS NORTH OF SAGINAW BAY, MICH.

Following roughly the coast line at a distance of 40 to 50 miles northerly from Saginaw Bay to Mackinaw is what may be termed a "fall line," forming the border of the central plateau of the State. A descent of 200 to 300 feet occurs here within a short distance. The longer streams, rising in the plateau at an elevation of 1,000 to 1,300 feet above sea level, make a rapid descent in crossing this slope. The principal streams of the region, all of which are tributary to Lake Huron, are as follows:[a]

Stream.	Drainage area at mouth.
	Square miles.
Rifle River	385
Au Gres River	478
Au Sable River	1,932
Thunder Bay River	1,267
Cheboygan River	1,594

The rainfall of the basins increases as we pass downstream, ranging from 25 or 30 inches a year in the vicinity of the sources to 35 or 40 inches at the mouths of the streams. The region is largely underlain by Coldwater shales, some of which are nearly pure calcium carbonate. There is a cover of Pleistocene deposits of varying thickness, the soil being largely sand, with wet plains, morainal hills, and undrained hollows. All these features are conducive to the direct retention of the precipitation. The ground waters, passing down to the alluvial clay deposits of the lower lake extension, travel along the clay horizon, entering the stream valleys as springs and seepage. At the middle of the last century this region bore an almost incalculable wealth of white-pine timber, which is now practically destroyed, leaving the sand plain barren or covered with jack pines, with occasional hard-wood swamp hollows. During the dry summer season of 1902 a series of discharge measurements were made on the streams of this locality. In order that the drought during which the summer flow was measured may be compared in intensity with those of other years, the following table is given, showing the meteorological conditions which prevailed while measurements were in progress:

[a] Horton, Robert E., Available Water Power of Michigan: Michigan Engineer, 1901, pp. 73–92.

Rainfall, northern part of Southern Peninsula, Michigan.

Days on which rain fell.	Precipitation in inches at—						
	Cheboygan.	Onaway.	Alpena.	Mio.	East Tawas.	West Branch.	Omer.
1902.							
August 10	Trace.	0.09	0.57	0.07	.....	.....	.....
August 11	.....	Trace.	.01	.14	0.13	Trace.	.....
August 13	.....	.....	.....	.01	.....	.....	.....
August 17	.....	.11	.02	.01	.....	.....	.....
August 18	0.66	.62	1.30	.50	.89	.....	.....
August 19	.....	.10	.02	.....	.....	.....	.....
August 20	Trace.	.08	.06	.24	Trace.	.....	Trace.
August 31	.23	.05	.09	.38	.67	0.05	.....
September 1	.10	.....	.14	.....	.....	.....	.....
September 3	.16	.31	.12	.12	.05	.....	Trace.
September 4	.18	.24	.01	Trace.	.....	.....	.....
September 6	Trace.	.....	.12	.12	.32	.10	0.10
September 7	.....	.....	.01	.....	.....	.....	.05
September 9	.....	.54	.35	.18	.....	.38	.56
September 10	.....	.....	.02	.....	.....	.....	.....
September 13	.....	.....	.01	.02	.62	.05	.....

The following notes relative to the several streams have been furnished by W. M. Gregory.[a] The elevations were obtained by aneroid or from railroad profile.[b]

Au Gres River rises in Stiles Lake. A lumbering dam 8 feet high controls the lake level. The greatest available fall occurs in the vicinity of the Detroit and Mackinaw Railroad near Whittemore. The river is here at an elevation of 655 feet.

The East Branch of Au Gres River in sec. 28, T. 22 N., R. 6 E., has high banks and flows over a rock bed. The fall is rapid.

Tawas River in Iosca County has its source in a small group of glacial lakes in sec. 31, T. 23 N., R. 7 E. It flows eastward between high clay banks, and has an elevation at the southeast corner of sec. 24 of this township of 666 feet.

Pine River in Arenac County has a fall of 44 feet between Standish and Saginaw Bay.

Nearly all the streams have one or more small lumber dams constructed of logs, many of which are abandoned.

The streams are located in an artesian basin which has recently been extensively utilized. In some cases the flow from the large numbers of wells undoubtedly increases the low-water stream discharge to some extent. The flowing wells waste in some cases directly on the sandy soil, their waters being absorbed and appearing later as springs or seepage. In regions of clay soil direct drains are dug to the water courses.

[a] Preliminary Report on Geology of Arenac County, Mich., pp. 21-23.

[b] In reference to the elevations given, it should be borne in mind that Lake Huron has an average water-service elevation of 581 feet.

In the limestone region north of Thunder Bay, there is also watershed leakage, occasioned by fissures in the lime rock. Through the gradual southwesterly tilting of the State the basins of the streams are undoubtedly increasing northward as far as Cheboygan River. In the Cheboygan drainage basin are a series of coast lakes, probably left as bayous by the recession of earlier Great Lake extensions. These have been encroached upon by sand and silt, forming inland lagoons lying below the 700-foot contour and having short outlets with little fall.

The following table gives the measured discharge and the drainage areas of the several streams. The measurements were mostly made by W. M. Gregory.

Low-water discharge of streams north of Saginaw Bay.

Date.	Stream.	Location.	Second-feet.	Drainage area.	Second-feet per square mile.
1902.				*Sq. miles.*	
Aug. 15	Rifle River	Omer [a]	244.3	364	0.67
Sept. 2	do	do [b]	222.9	364	.61
13	do	do [c]	290.7	364	.79
1	Au Gres River	Au Gres [d]	98.3	422	.23
8	East Branch Au Gres River.	Near Au Gres [e]	60.2	170	.35
Aug. 19	Tawas River	Tawas City [f]	53.3	125	.42
26	Au Sable River	Bamfield [g]	1,026.0	1,425	.72
Sept. 17	do	do	839.0	1,425	.59
Oct. 7	do	do	981.0	1,425	.69
Aug. 27	Pine River	Indian bridge [h]	111.0	231	.48
27	do	Near Indian bridge [i]	106.0	231	.46
28	Black River	Near Black River [j]	30.0	65	.46
Sept. 4	South Branch Thunder Bay River.	Below King Creek [k]	117.0	295	.39
4	North Branch Thunder Bay River.	Mouth [l]	13.6	200	.06
Aug. 13	Thunder Bay River	2 miles above Alpena [m]	1,537.0	1,265	1.21
Sept. 14	Ocqueoc River	Brader bridge [n]	8.5	58	.14

[a] Gage 4.91. [b] Gage 4.85. [c] Gage 5.28. [d] W. S. 14.4 below top left-hand abutment.

[e] Measured near mouth, north of Au Gres, Mich.

[f] Water surface 10.45 feet below top of left-hand abutment.

[g] August 26, gage not set. September 17, gage 0.80. October 7, gage 0.72.

[h] Water surface 4.85 feet below top of left-hand bridge abutment.

[i] Measured 150 feet below Indian bridge; tributary to Au Sable near mouth.

[j] Stream fed by springs from Alcona morraine. Considerable fall utilized. Water surface 8.1 feet below top of bowlder on left-hand bank.

[k] Sec. 21, T. 31 N., R. 7 E. Water surface 9.28 feet below top of left-hand abutment.

[l] Sec. 33, T. 32 N., R. 7 E., mouth of river.

[m] At Red bridge, 2 miles below Fletcher dam.

[n] Sec. 33, T. 35 N., R. 3 E.

Low-water discharge of streams north of Saginaw Bay—Continued.

CHEBOYGAN RIVER DRAINAGE.

Date.	Stream.	Location.	Second-feet.	Drainage area.	Second-feet per square mile.
1902.				*Sq. miles.*	
Sept. 8	Black River	5 miles above Black Lake.	175.0	369	0.47
12	Rainy River	Near Onoway[a]	7.8	100	.07
13	Black Lake Outlet	Near Sova[b]	175.0	612	.28
15	Cheboygan River	County house[c]	522.4	939	.55
15	Indian River	Indian River[d]	463.8	660	.47

[a] Drinker bridge, sec. 24, T. 35 N., R. 2 E.
[b] At covered bridge, sec. 18, T. 34 N., R. 2 E. Water surface 9.35 feet below top of right-hand abutment.
[c] Sec. 18, T. 37 N., R. 1 W. Water surface 5.9 feet below top of left-hand abutment.
[d] Water surface 9.9 feet below top of left-hand abutment.

FOX RIVER DRAINAGE BASIN.

Fox River connects Lakes Poygan, Winnebago, and Butte des Mortes with Lake Michigan; it enters the latter lake in Green Bay, near the city of Green Bay. The principal tributary in this basin is Wolf River, which rises in Forest County, Wis., and flows south into Lake Poygan.

Lake Winnebago is the largest inland lake in Wisconsin, being 26 miles long and having a maximum width of 10 miles. Its area is 212 square miles. The United States Geological Survey is maintaining, in cooperation with the Wisconsin Geological and Natural History Survey, the following stations in this drainage: On Fox River at Omro, Oshkosh, and Wrightstown, and on the Wolf River at Winneconne. The Omro, Oshkosh, and Winneconne stations measure practically all the water flowing into Lake Winnebago, while the station on the lower Fox River at Wrightstown measures all the discharge from this lake. It is hoped that a careful analysis of the discharge measurements secured at these stations will throw some light on the rate of evaporation over water surfaces in this latitude.

FOX RIVER AT OMRO, WIS.

This station was established November 22, 1902, by L. R. Stockman. It is located on the city bridge in Omro, Wis. The gage is a plain staff, graduated to feet and tenths. It is fastened to a pile in the center guard pier. It is read twice daily by William Herner. The stream is straight for a thousand feet both above and below the station; the right bank is high, the left bank is low; neither is liable to overflow. The bed of the stream is black loam. The initial point for

sounding is on the right bank at a nail in the footboard of the bridge. The bench mark is on the water table of the southwest corner of Robinson's store; elevation, 14.24 feet above zero of gage.

Elevation of bench mark No. 2, 8.97 feet above zero of gage.

The following discharge measurements were made during 1902:

November 22: Gage height, 4.60 feet; discharge, 680 second-feet.
December 13: Gage height, 4.50 feet; discharge, 600 second-feet.

Daily gage height, in feet, of Fox River at Omro, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		4.65	12		4.50	23		4.80
2		4.60	13		4.50	24		4.80
3		4.65	14		4.50	25	4.70	4.80
4		4.65	15		4.50	26	4.75	4.70
5		4.70	16		4.55	27	4.60	4.70
6		4.70	17		4.50	28	4.50	4.70
7		4.50	18		4.55	29	4.60	4.75
8		4.50	19		4.55	30	4.50	4.80
9		4.50	20		4.65	31		4.80
10		4.50	21		4.70			
11		4.50	22		4.80			

FOX RIVER AT OSHKOSH, WIS.

This station was established November 26, 1902, by L. R. Stockman. It was located at the Wisconsin avenue highway bridge in Oshkosh, Wis. The gage was a plain staff, graduated to feet and tenths, and fastened to the guard of the center pier. It was read twice daily by the bridge tender. The channel is straight, both above and below the station. The right bank is low, and the left bank is high; neither is very liable to overflow. The bed of the stream is loam and clay. The initial point for sounding is a nail in the footboard at the left end of the bridge. Two bench marks are located on the piers of the bridge. This station was discontinued soon after it was established, because it was found that, as a result of its proximity to Lake Winnebago, the elevation of the water depended as much upon the direction of the wind as upon the volume of the discharge. Besides, lumber rafts anchored at this bridge made observations for discharge both difficult and unreliable.

The following discharge measurement was made in 1902:

November 26: Gage height, 4.15 feet; discharge, 4,932 second-feet.

Daily gage height, in feet, of Fox River at Oshkosh, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1	.....	4.05	12	.....	4.05	23	.....	4.1
2	.....	4.15	13	.....	4.0	24	.....	4.1
3	.....	4.15	14	.....	4.0	25	.....	4.05
4	.....	4.10	15	.....	4.0	26	4.15	4.1
5	.....	4.10	16	.....	4.0	27	4.2	4.1
6	.....	4.10	17	.....	4.0	28	4.1	4.1
7	.....	4.10	18	.....	4.0	29	3.9	4.1
8	.....	4.05	19	.....	4.0	30	3.95	4.1
9	.....	4.05	20	.....	4.05	31	.....	4.1
10	.....	4.05	21	.....	4.05			
11	.....	4.05	22	.....	4.05			

FOX RIVER AT WRIGHTSTOWN, WIS.

This station was established November 19, 1902, by L. R. Stockman. It is located on the highway bridge in Wrightstown, Wis. The gage is a plain staff, graduated to feet and tenths, and fastened to the pile in the guard to the center pier. It is read twice daily by Peter Van Lieshout. The initial point of sounding is a nail in the footboard on the left end of the bridge. The channel is straight for three-fourths of a mile above the bridge, and for a short distance below. The right bank is low and the left bank is high; neither bank is liable to overflow. The bed of the stream is gravelly loam. The bench mark is a projecting stone in the northwest corner of the foundation of the American House, 2 feet from the corner. Elevation above zero of gage is 20.21 feet. Elevation above bench mark No. 2 is 12.46 feet.

The following discharge measurements were made during 1902:

November 19: Gage height, 6.4 feet; discharge, 3,284 second-feet.
November 20: Gage height, 6.4 feet; discharge, 3,238 second-feet.
December 11: Gage height, 6.6 feet; discharge, 3,563 second-feet.

Daily gage height, in feet, of Fox River at Wrightstown, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1	.....	6.45	12	.....	6.50	23	5.40	6.35
2	.....	6.45	13	.....	6.50	24	5.48	6.30
3	.....	6.50	14	.....	5.70	25	6.45	5.60
4	.....	6.55	15	.....	5.50	26	6.55	5.50
5	.....	6.50	16	.....	6.55	27	6.50	6.35
6	.....	6.55	17	.....	6.45	28	6.45	5.60
7	.....	5.50	18	.....	6.40	29	6.50	5.45
8	.....	5.75	19	6.40	6.40	30	5.30	6.25
9	.....	6.40	20	6.45	6.45	31	.....	6.40
10	.....	6.45	21	6.45	5.70			
11	.....	6.60	22	6.45	5.45			

WOLF RIVER AT WINNECONNE, WIS.

This station was established November 24, 1902, by L. R. Stockman. It is on the town highway bridge in Winneconne, Wis. The gage is a plain staff, graduated to feet and tenths, and fastened to one of the bridge piles. It is read twice daily by C. P. O'Toole. The channel is straight both above and below the bridge. The right bank is high and the left bank is low. They never overflow. The bed of the stream is loam. The bench mark is on the water table in the northeast corner of the Union Bank; elevation, 12.81 feet above zero of gage. The initial point of sounding is a nail in the footboard on the left bank.

The following measurements were made during 1902:

November 24: Gage height, 5.6 feet; discharge, 4,430 second feet.
December 15: Gage height, 5.4 feet; discharge, 1,144 second feet.

Daily gage height, in feet, of Wolf River at Winneconne, Wis.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1	.....	5.50	12	.....	5.40	23	.....	5.50
2	.....	5.50	13	.....	5.40	24	5.55	5.50
3	.....	5.50	14	.....	5.40	25	5.60	5.50
4	.....	5.50	15	.....	5.40	26	5.55	5.50
5	.....	5.50	16	.....	5.40	27	5.50	5.50
6	.....	5.50	17	.....	5.40	28	5.50	5.50
7	.....	5.50	18	.....	5.40	29	5.60	5.50
8	.....	5.50	19	.....	5.40	30	5.50	5.50
9	.....	5.50	20	.....	5.40	31	.....	5.50
10	.....	5.50	21	.....	5.50			
11	.....	5.45	22	.....	5.50			

INDEX.

Page.

Agricultural College, Mich., stream measurements at 283-284
Alabama River, measurements of, at Montgomery, Ala..... 133-134
measurements of, at Selma, Ala..... 131-133
Albany, Ga., stream measurements at... 114-117, 127, 128
Alcovy River, Georgia, measurements of. 111-113
Alderson, W. Va., stream measurements at. 188-190
Alexander, Ala., stream measurements near..... 139-141
Allegan, Mich., stream measurements near..... 267-271
Alligator Creek, Georgia, measurement of. 113
Alpena, Mich., stream measurements near..... 289-293, 296
Alston, S. C., stream measurements near... 82-84
Altamaha River, Georgia, stream measurements in basin of..... 96-113
Apalachee River, Georgia, measurements of..... 104-106
Apalachicola River, stream measurements in basin of..... 114-128
Athens, Ga., stream measurements near. 101-103
Atlanta, Ga., stream measurement near... 127
Au Gres, Mich., stream measurement near. 296
Au Gres River, Michigan, measurements of. 296
Au Sable River, Michigan, course and character of basin of 287-288
measurements of 288-289, 296
Aucheehachee Creek, Georgia, measurements of..... 113
Augusta, Ga., stream measurements at..... 87-89
Austell, Ga., stream measurements near. 127, 128
Bamfield, Mich., stream measurements at. 288-289, 296
Barnett Shoals, Georgia, stream measurements near 99-101
Beaverdam Creek, South Carolina, measurements of 95
Big Creek, Georgia, measurement of 95
Black Lake Outlet, Michigan, measurement of..... 297
Black River, Michigan, measurement of... 296
Black River, Wisconsin, measurements of. 167-168
Black Warrior River, measurements of, at Tuscaloosa, Ala 154-156
measurements of, near Cordova, Ala. 156-158
Blanchard River, Ohio, measurements of.. 240
Blueridge, Ga., stream measurements near..... 208-210
Bluff City, Tenn., stream measurements at..... 227-229
Bridgewater, N. C., stream measurements near..... 80-82
Brier Creek, Georgia, measurements of 95
Broad River, Georgia, measurements of.... 92-94

Page.

Broad River (of the Carolinas), course and character of 70
measurements of 82-84
Brule River, Michigan, drainage areas of.. 252
Brunt, N. C., stream measurements near... 48-49
Bryson, N. C., stream measurements at.. 218-220
Buchanan, Mich., stream measurements at..... 262-265
Buckhead, Ga., stream measurements near 104-106
Buckhead Creek, Georgia, measurements of. 95
Buckhorn Falls, N. C., water power at..... 28
Burnside, Ky., stream measurement at 202
Butler, Tenn., stream measurements at.. 229-235
Cahaba River, Alabama, measurements of..... 129-130
Calhoun Falls, S. C., stream measurements near 90-92, 95
Canton, Ga., stream measurements at.... 148-151
Cape Fear River, North Carolina, fall of ... 27
gaging stations, rainfall stations, and water-power plants in basin of, map showing..... 58
measurements of 31-48
rainfall in basin of 51-60
relation of rainfall to run-off in basin of, diagrams showing 59
stream measurements in basin of..... 26-51
water powers in basin of 27-31
Carlton, Ga., stream measurements near... 92-94
Carp River, Michigan, measurements of. 247-249
Carters, Ga., stream measurements at. 151-153, 164
Catawba, N. C., stream measurements at .. 73-74
Catawba River, measurements of, at Catawba, N. C..... 73-74
measurements of, near Morgantown, N. C 75-77
near Rockhill, S. C..... 71-73
Catfish River, Wisconsin, measurements of..... 170-171
Centerville, Ala., stream measurements at 129-130
Channahon, Ill., gaging stations near, descriptions of 174, 175
Chapel Hill, N. C., rainfall at 55
Charleston, Tenn., stream measurements at..... 205-207
Chattahoochee River, measurements of, at Oakdale, Ga..... 122-124
measurements of, at West Point, Ga.. 119-121
miscellaneous 127, 128
near Gainesville, Ga..... 125-127
Chattanooga, Tenn., stream measurements at..... 203-205
Cheat River, West Virginia, measurements of..... 184-185
Cheboygan River, Michigan, measurement of..... 297

Page.
Chestatee River, Georgia, measurement of. 127
Chippewa River, Wisconsin, measurements of..... 166-167
Chucky Valley, Tenn., stream measurements near..... 224-227
Clearfield, Tenn., stream measurement near..... 202
Clinch River, Tennessee, measurement of.. 235
Clinton, Tenn., stream measurement near. 235
Coal Creek, Tennessee, measurement of ... 235
Columbus, Ga., stream measurements near. 128
Columbus, Miss., stream measurements at..... 161-163, 164
Congaree River, North Carolina, course and character of 70
Coosa River, measurements of, at Riverside, Ala 143-145
measurements of, at Rome, Ga..... 146-148
Coosawattee River, Georgia, measurements of..... 151-153
Cordova, Ala., stream measurements near..... 156-158
Covington, Ga., stream measurements near..... 111-113
Crockery Creek, Michigan, measurements of..... 277-279
Cumberland River, measurements of 200-202
Cumnock, N. C., stream measurements at.. 49-51
Dams, law concerning, on Michigan streams..... 244
Dan River, measurements of..... 19-21
Dawson, Ga., stream measurement near ... 164
Dead River, Michigan, fall of..... 245-246
measurements of 246-247
Deep River, North Carolina, measurements of..... 49-51
fall of..... 27
Desplaines River, Illinois, gaging stations on, descriptions of..... 174-175
Dublin, Ga., stream measurements at 96-99
Eau Claire, Wis., stream measurements near..... 166-167
Etowah River, Georgia, measurements of.. 148-151, 164
Euharlee, Ga., stream measurement near.. 164
Euharlee Creek, Georgia, measurements of. 164
Fayette, W. Va., stream measurements at. 186-187
Fayetteville, N. C., rainfall at..... 54
stream measurements at 31-48
Flint River, measurements of, at Albany, Ga 114-117
measurements of, near Woodbury, Ga. 117-119
Flintstone, Ga., stream measurement near. 235
Flovilla, Ga., stream measurements near. 110-111
Fox River, Illinois, gaging station on, description of..... 173
Fox River, Wisconsin, measurement of, at Omro, Wis..... 297-298
measurements of, at Oshkosh, Wis ... 298-299
at Wrightstown, Wis..... 299
French Broad River, Tennessee, measurements of..... 223
Friendsville, Md., stream measurements at..... 182-184
Gaging stations, location of, map showing. 12, 13
Gainesville, Ga., stream measurements near..... 125-127

Page.
Grand Rapids, Mich., stream measurements at..... 272-277
Grand River, measurements of, at Grand Rapids, Mich..... 272-277
measurements of, at North Lansing, Mich..... 279-283
stream measurements in basin of..... 271-284
Greenbrier River, West Virginia, measurements of..... 188-190
Greensboro, N. C., rainfall at..... 56
Haw River, North Carolina, fall of..... 27
Hillabee Creek, Alabama, measurements of..... 139-141
Hiwassee River, measurements of, at Charleston, Tenn..... 205-207
measurements of, at Murphy, N. C... 214-216
at Reliance, Tenn 210-212
Holston River, Tennessee, measurements of..... 227-229
Illinois River, gaging stations in basin of, descriptions of..... 171-175
Indian River, Michigan, measurement of.. 297
Iron Mountain, Mich., stream measurements near..... 257-258
Iron River, Michigan, measurements of.. 259-262
Irrigation projects, location of, map showing 12
Jackson, Miss., stream measurements near 164-165
John River, North Carolina, measurements of..... 77-80
Jonathan Creek, Ohio, measurements of... 181
Judson, N. C., stream measurements at .. 216-218
Kalamazoo River, Michigan, course and character of basin of 266-267
measurements of 267-271
Kanawha River, stream measurements in basin of 185-200
Kinchafoonee Creek, Georgia, measurements of..... 127, 128
Kingston, Ga., stream measurement near.. 164
Knoxville, Tenn., stream measurements at..... 220-222
Lafayette, Ind., steam measurements at . 177-180
Lasalle, Ill., gaging station at, description of. 172
Licking River, Ohio, measurements of... 181-182
Lima, Ohio, stream measurements near.. 240-241
Linville River, North Carolina, measurements of..... 80-82
Little Ocmulgee River, Georgia, measurements of 113
Little River, Georgia, measurement of... 113, 127
Little River, North Carolina, measurements of..... 51
Little Tennessee River, measurements of. 216-218
Locust Fork of Black Warrior River, Alabama, measurements of..... 159-161
Louisville, Ga., stream measurements near. 95
Lower Quinnesec Falls, Wisconsin, stream measurements at 255-257
Lumber City, Ga., stream measurements near..... 113
Luxapelila Creek, Mississippi, measurements of..... 164
Macon, Ga., stream measurements at 107-109
Madison, Wis., stream measurements at . 170-171
Manchester, N. C., stream measurements near..... 51

Page.
Marquette, Mich., stream measurements near 248-250
Maumee River, Ohio, gaging station on, description of 239
stream measurements in basin of 239-241
Melrose, Wis., stream measurements at .. 167-168
Mendon, Mich., stream measurements at. 265-266
Menominee River, Michigan, drainage areas of 253
logs and lumber scaled on 255
lumbermen's dams on 254
measurements of, at Lower Quinnesec Falls, Wisconsin 255-257
near Iron Mountain, Mich 257-258
tributaries of 250-252
Meriwether, Ga., stream measurement near. 113
Merrill Wis., stream measurements at 170
Michigamme River, Michigan, drainage areas of 253
Michigan, dams on streams in, law concerning 244
hydrographic features of 241-245
land and water surface of 241
public water-supply systems in 243
rainfall in northern part of Southern Peninsula 295
timber floated on streams in 243
water power in use in 245
Middle Oconee River, measurements of ... 101-103, 113
Milledgeville, Ga., stream measurement at. 113
Millen, Ga., stream measurements near.... 95
Milstead, Ala., stream measurements at.. 134-136
Minooka, Ill., gaging station near, description of 174
Mobile River, stream measurements in basin of 128-164
Moncure, N. C., rainfall at 54
Monongahela River, stream measurements in basin of 182-185
Montgomery, Ala., stream measurements at 133-134
Morganton, N. C., stream measurements near 75-80
Morgantown, W. Va., stream measurements near 184-185
Muckalee Creek, Georgia, measurements of 127, 128
Murphy, N. C., stream measurements at.. 214-216
Muscoda, Wis., stream measurements at. 168-169
Muskegon River, Michigan, gaging station on, description of 285
Muskingum River, Ohio, stream measurements in basin on 180-182
Nashville, Tenn., stream measurements at. 200-201
Neal, N. C., stream measurements at..... 16-18
Necedah, Wis., stream measurements near. 169
Negaunee, Mich., stream measurements near 246-247
Newaygo, Mich., gaging station at, description of 285
Newport, Tenn., stream measurements at and near 223-224
New River, measurements of, at Fayette, W. Va 186-187
measurements of, at New River, N. C. 198-200
at Radford, Va 190-191
at Weaversford, N. C 194-197
near Oldtown, Va 191-194
Page.
New River, N. C., stream measurements at 198-200
Nolichucky River, Tennessee, measurements of 224-227
Norcross, Ga., stream measurements near.. 127
North Lansing, Mich., stream measurements at 279-283
Nottely River, North Carolina, measurements of 212-214
Nottingham, Ala., stream measurements at 142-143
Oakridge, N. C., rainfall at 56
Oakdale, Ga., stream measurements near. 122-124
Ocmulgee River, measurements of, at Macon, Ga 107-109
measurements of, near Flovilla, Ga 110-111, 113
near Lumber City, Ga 113
Oconee Creek, Georgia, measurement of ... 113
Oconee River, measurements of, at Dublin, Ga 98-99
measurements of, miscellaneous 113
near Barnett Shoals, Ga 99-101
Ocqueoc River, Michigan, measurement of. 296
Ogeechee River, Georgia, stream measurements in basin of 95
Okoee River. *See* Toccoa River.
Oldtown, Va., stream measurements near. 191-194
Omer, Mich., stream measurements at..... 286-287, 296
Omro, Wis., stream measurements at 297-298
Onoway, Mich., stream measurement near. 297
Oshkosh, Wis., stream measurements at.. 298-299
Ottawa, Ill., gaging stations at, descriptions of 172
Ottawa, Ohio, stream measurements at 240
Ottawa River, Ohio, measurements of ... 240-241
Paint River, Michigan, drainage areas of .. 253
Palos, Ala., stream measurements at..... 159-161
Peachtree Creek, Georgia, measurement of. 127
Pearl River, Mississippi, measurements of. 164-165
Pedee River, North Carolina, rainfall and floods on 61
stream measurements in basin of 60-68
Peoria, Ill., gaging station near, description of 172
Pigeon River, Tennessee, measurements of 223-224
Pine River, Michigan, measurements of ... 296
Pittsboro, N. C., rainfall at 55
Pleasant Valley, Ohio, stream measurements at 181-182
Powells, Ohio, stream measurements at.... 181
Precipitation. *See* Rainfall.
Radford, Va., stream measurements at .. 190-191
Rainfall in Cape Fear River Basin, North Carolina 51-60
in Michigan, northern part of Southern Peninsula 295
Rainy River, Michigan, measurement of .. 297
Randolph, Va., stream measurements at... 21-23
Ranger, N. C., stream measurements at.. 212-214
Red Cedar River, Michigan, measurements of 283-284
Reliance, Tenn., stream measurements at. 210-212
Rifle River, Michigan, course and character of basin of 285
measurements of 286-287, 296

Page.
River stations, location of, map showing... 12, 13
Riverside, Ala., stream measurements at. 143-145
Riverton mine, Michigan, stream measurements at..... 259-262
Roan Creek, Tennessee, measurements of. 232-235
Roanoke, Va., stream measurements at.... 24-26
Roanoke River, measurements of, at Neal, N. C 16-18
measurements of, at Roanoke, Va..... 24-25
stream measurements in basin of 15-25
Roaring Creek, Georgia, measurement of .. 128
Rock Creek, Georgia, measurement of 235
Rock River, Wisconsin, stream measurements in basin of..... 170-171
Rockfish Creek, North Carolina, measurements of..... 48-49
Rockhill, S. C., stream measurements near. 71-73
Rockmart, Ga., stream measurements at... 164
Rocky River, South Carolina, stream measurements near..... 95
Rome, Ga., stream measurements at..... 146-148
Saginaw Bay, Michigan, streams north of, low-water measurements of .. 294-297
Salisbury, N. C., stream measurements near. 61-64
Saluda River, South Carolina, course and character of 70
measurements of 84-86
Santee River, North Carolina, stream measurements in basin of 68-86
Savannah River, measurements of, at Augusta, Ga 87-89
measurements of, near Calhoun Falls, S. C..... 90-92
stream measurements in basin of 87-95
St. Joseph River, Michigan, course and character of basin of..... 262
measurements of, at Buchanan, Mich. 262-265
at Mendon, Mich 265-266
Selma, Ala., stream measurements at.... 131-133
Seneca, Ill., gaging station at, description of..... 173
Siloam, N. C., stream measurements at 64-68
Slocums Grove, Mich., stream measurements at..... 277-279
Smileys Falls, N. C., water power at 28
Soapstone Mountain, North Carolina, rainfall at 55
South Boston, Va., stream measurements at. 19-21
Southern Pines, N. C., rainfall at 54
Sova, Mich., stream measurements near... 297
Standingboy Creek, Georgia, measurement of..... 128
Staunton River, measurements of..... 21-23
Sturdevant, Ala., stream measurements at..... 137-139
Sweetwater Creek, Georgia, measurements of..... 127, 128
Talking Rock Creek, Georgia, measurement of..... 164
Talladega Creek, Alabama, measurements of..... 142-143
Tallahassee Shoals, Georgia, stream measurement at 113
Tallapoosa River, measurements of, at Millstead, Ala 134-136
measurements of, at Sturdevant, Ala. 137-139
at Tallapoosa, Ga..... 164
Tawas City, Mich., stream measurement at. 296
Tawas River, Michigan, measurement of .. 296
Tennessee River, measurements of, at Chattanooga, Tenn..... 203-205
measurements of, at Knoxville, Tenn. 220-222
stream measurements in basin of..... 202-235
Terre Haute, Ind., stream measurements at..... 176-177
Thunder Bay River, Michigan, measurements of..... 289-293, 296
Toccoa Creek, Georgia, measurement of ... 95
Toccoa Falls, Georgia, stream measurement at..... 95
Toccoa River, measurements of..... 208-210
Tombigbee River, Mississippi, measurements of..... 161-163
Tuckasegee River, measurements of..... 218-220
Tuscaloosa, Ala., stream measurements at..... 154-156
Wabash River, Illinois, altitudes and distances along..... 176
measurements of, at Lafayette, Ind.. 177-180
at Terre Haute, Ind 176-177
Wadley, Ga., stream measurements at 95
Watauga River, Tennessee, measurements of..... 229-232
Water power in use in Michigan 245
Wateree River, North Carolina, course and character of 69
Waterloo, S. C., stream measurements near 84-86
Waterville, Ohio, gaging station at, description of..... 239
Waynesboro, Ga., stream measurements at. 95
Weaversford, N. C., stream measurements near 194-197
Westpoint, Ga., stream measurements at.. 119-121
Williamsons Swamp Creek, Georgia, measurements of 95
Winneconne, Wis., stream measurements at 300
Wisconsin River, measurements of, at Merrill, Wis..... 170
measurements of, at Muscoda, Wis. 168-169
near Necedah, Wis 169
Wolf River, Wisconsin, measurements of .. 300
Woodbury, Ga., stream measurements near 117-119
Wrightstown, Wis., stream measurements at 299
Yadkin River, measurements of, at Siloam, N. C 64-68
measurements of, near Salisbury, N. C. 61-64
rainfall and floods on 61
stream measurements in basin of 60-68
Yazoo City, Miss., stream measurements at..... 235-238
Yazoo River, Mississippi, measurements of..... 235-238
Youghiogheny River, Maryland, measurements of..... 182-184

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1902

BY

F. H. NEWELL

PART III.—WESTERN MISSISSIPPI AND WESTERN GULF DRAINAGE

WASHINGTON
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CONTENTS.

	Page.
Letter of transmittal	7
Introduction	9
Acknowledgments	12
Western Mississippi River drainage	13
Missouri River drainage basin	13
Marais des Cygnes River at Ottawa, Kans	14
Big Sioux River near Watertown, S. Dak	15
Niobrara River at Niobrara, Nebr	16
Niobrara River at Valentine, Nebr	18
Clear Creek at Buffalo, Wyo	20
Piney Creek at Kearney, Wyo	21
Shoshone River at Cody, Wyo	21
Bighorn River near Thermopolis, Wyo	23
Yellowstone River near Livingston, Mont	24
Milk River at Malta, Mont	26
Milk River at Havre, Mont	28
Musselshell River at Shawmut, Mont	31
Marias River near Shelby, Mont	32
Two Medicine Creek at Midvale, Mont	34
Missouri River at Cascade, Mont	35
Missouri River at Townsend, Mont	36
Gallatin River at Logan, Mont	38
West Gallatin River near Salesville, Mont	40
Middle Creek near Bozeman, Mont	43
Madison River near Redbluff, Mont	46
Jefferson River at Sappington, Mont	47
Miscellaneous measurements in Missouri River drainage basin	49
Platte River drainage basin	50
Elkhorn River near Arlington, Nebr	51
Elkhorn River near Norfolk, Nebr	53
Loup River at Columbus, Nebr	55
Platte River near Columbus, Nebr	57
Platte River near Lexington, Nebr	59
North Platte River at North Platte, Nebr	62
North Platte River at Bridgeport, Nebr	64
North Platte River at Mitchell, Nebr	66
North Platte River at Guernsey, Wyo	68
Little Laramie River at May's ranch near Hatton, Wyo	70
Sweetwater River at Devils Gate near Splitrock, Wyo	72
South Platte River at Bigspring, Nebr	72
South Platte River at Julesburg, Colo	73
Middle Crow Creek near Hecla, Wyo	75
South Platte River at Kersey, Colo	77

Western Mississippi River drainage—Continued.
Platte River drainage basin—Continued. Page.
Big Thompson Creek near Arkins, Colo 79
St. Vrain Creek at Lyons, Colo 81
Clear Creek at Forkscreek, Colo 84
South Platte River at Denver, Colo 86
Bear Creek near Morrison, Colo 89
South Platte River at South Platte, Colo 89
Miscellaneous measurements in the Platte River drainage basin 92
Kansas River drainage basin 95
Kansas or Kaw River at Lecompton, Kans 95
Blue River near Manhattan, Kans 97
Republican River at Junction, Kans 100
Republican River and the mill race near Superior, Nebr 102
Solomon River at Niles, Kans 105
Saline River near Salina, Kans 108
Smoky Hill River at Ellsworth, Kans 110
Miscellaneous measurements in the Kansas River drainage basin 112
Arkansas River drainage basin 113
Canadian River (North Fork) near Elreno, Okla 114
Neosho River at Iola, Kans 115
Verdigris River near Liberty, Kans 116
Walnut River at Arkansas City, Kans 119
Arkansas River at Arkansas City, Kans 119
Arkansas River at Hutchinson, Kans 120
Arkansas River at Dodge, Kans 123
Arkansas River at Syracuse, Kans 123
Arkansas River at Barton, Colo 125
Arkansas River near Rockyford, Colo 126
Arkansas River near Nepesta, Colo 128
Arkansas River at Pueblo, Colo 130
Arkansas River near Canyon, Colo 133
Arkansas River at Salida, Colo 136
Miscellaneous measurements in the Arkansas River drainage basin 138
Red River drainage basin 139
Washita River at Anadarko, Okla 139
Miscellaneous measurements in the Red River drainage basin 140
Western Gulf drainage 140
Sabine River drainage basin 140
Miscellaneous measurements in Sabine drainage basin 141
Neches River drainage basin 141
Miscellaneous measurements in Neches drainage basin 142
Trinity River drainage basin 142
Trinity River at Riverside, Tex 142
Brazos River drainage basin 143
Brazos River at Waco, Tex 143
Brazos River at Richmond, Tex 147
Little River and its tributaries 147
Colorado River (of Texas) drainage basin 148
Colorado River at Columbus, Tex 149
Colorado River at Austin, Tex 149
Miscellaneous measurements on Colorado River 152
Barton Springs, near Austin, Tex 152
Llano River, Tex 153
San Saba River, Tex 154

Western Gulf drainage—Continued. Page.
Guadalupe River drainage basin 156
Guadalupe River near Cuero, Tex 156
Miscellaneous measurements in Guadalupe River drainage basin .. 157
Rio Grande drainage basin 157
Rio Grande at Eagle Pass, Tex 158
Las Moras Creek, Tex 161
San Felipe Creek, Tex 161
Rio Grande below mouth of Devils River, Tex 161
Devils River at Devilsriver, Tex 164
Pecos River near Moorhead, Tex 166
Pecos River, Margueretta flume, and West Valley ditch, near Pecos, Tex 168
Rio Grande at Langtry, Tex 172
Rio Grande below Presidio, Tex 175
Rio Grande above Presidio, Tex 177
Rio Grande near Fort Hancock, Tex 179
Rio Grande near El Paso, Tex 181
Rio Grande near San Marcial, N. Mex 183
Rio Grande at Water Tank, near Rio Grande or Buckman, N. Mex. 186
Rio Grande at Embudo, N. Mex 189
Rio Grande near Cenicero, Colo 192
Rio Grande near Del Norte, Colo 194

ILLUSTRATIONS.

		Page.
FIG. 1.	Location of river stations and principal irrigation projects in western half of United States, 1902–3	10
2.	Location of river stations in eastern half of United States, 1902–3	11

LETTER OF TRANSMITTAL.

DEPARMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., June 29, 1903.

SIR: I have the honor to transmit herewith Water-Supply Paper No. 84, which is Part III of the Report of Progress of Stream Measurements for 1902. This paper contains the data which has been received during 1902 from that portion of the territory west of the Mississippi River which drains either into the Mississippi River or the western Gulf of Mexico. This paper will be followed by Water-Supply Paper No. 85, which will contain the data from the remainder of the Western States, and will also complete the Progress Report of Stream Measurements for 1902.

These papers contain, for the various gaging stations, the original data as collected and the results obtained from the discussion of these data, also such other information as is of interest in hydrographic studies.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1902.

PART III.

By F. H. NEWELL.

INTRODUCTION.

This paper contains the data collected in the territory which drains from the West either into the Gulf of Mexico or the Mississippi River, and for convenience in arrangement the material has been grouped under these two headings. This paper with Water-Supply Paper No. 85 make up the Progress Report of Stream Measurements for the territory west of the Mississippi River. The report for the territory east of the Mississippi River is contained in Water-Supply Papers Nos. 82 and 83. The material in each of these papers consists of both the original data as collected at the various river stations and the results obtained from the discussion of these data; also brief descriptions and facts regarding such other subjects as are allied to hydrographic studies.

For convenience in arrangement the data under the two main parts of this paper have been grouped by drainage areas and these have been arranged geographically from North to South.

In collecting hydrographic data the Geological Survey has received the hearty cooperation of various individuals, corporations, and States, as mentioned hereafter. This cooperation has made possible the publication of many valuable records which could not otherwise have been obtained.

A brief historical sketch of the stream measurements made by the Geological Survey is published on pages 11 to 15 of Water-Supply Paper No. 75.

On figs. 1 and 2 the full dots show the relative location of the stations at which the U. S. Geological Survey is collecting hydrographic data. The section west of the shaded line comprises those States which are

covered by the national irrigation act of June 17, 1902 (Stat. L., vol. 32, pp. 388–390), and the cross-lined areas show the location of the irrigation projects which are now under investigation.

The results of the stream measurements made during the past years

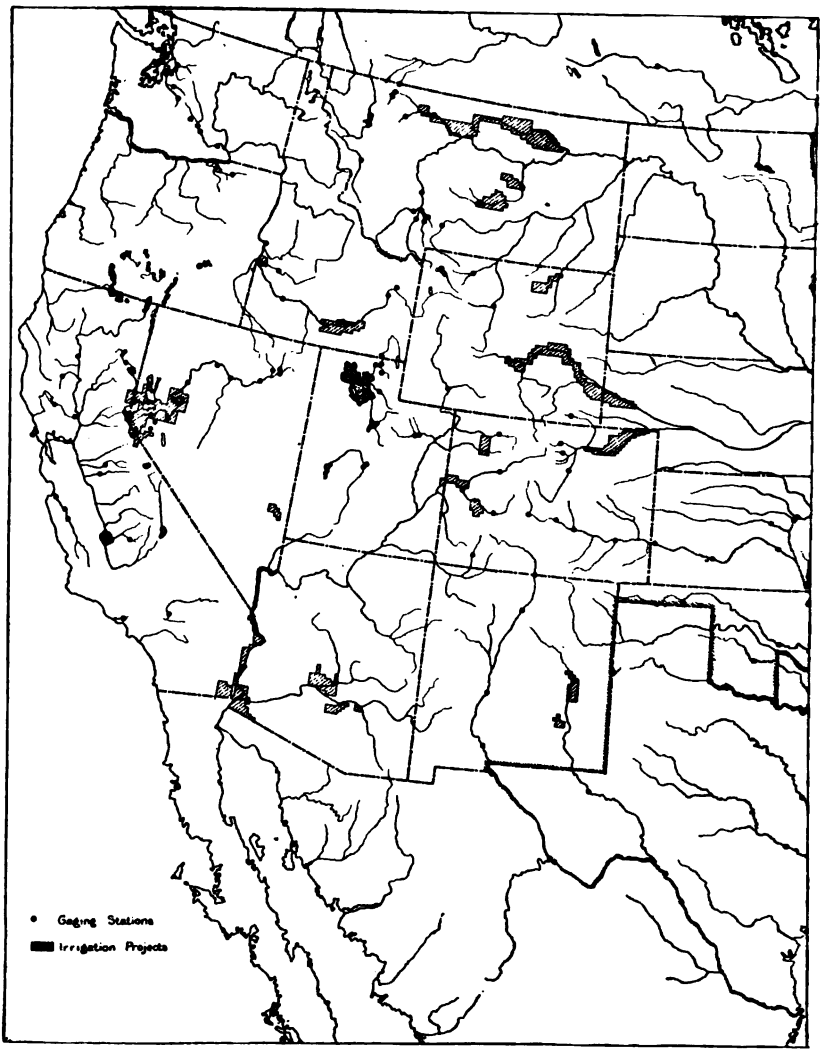

FIG. 1.—Location of river stations and principal irrigation projects in western half of United States, 1902–3.

by the U. S. Geological Survey can be found in the following publications, which may be consulted at the public libraries in most cities:

1893. Bulletin No. 131.
1894. Bulletin No. 131.
1895. Bulletin No. 140.

1896. Water-Supply Paper No. 11; Part IV of the Eighteenth Annual Report.

1897. Water-Supply Papers Nos. 15 and 16; Part IV of the Nineteenth Annual Report.

1898. Water-Supply Papers Nos. 27 and 28; Part IV of the Twentieth Annual Report.

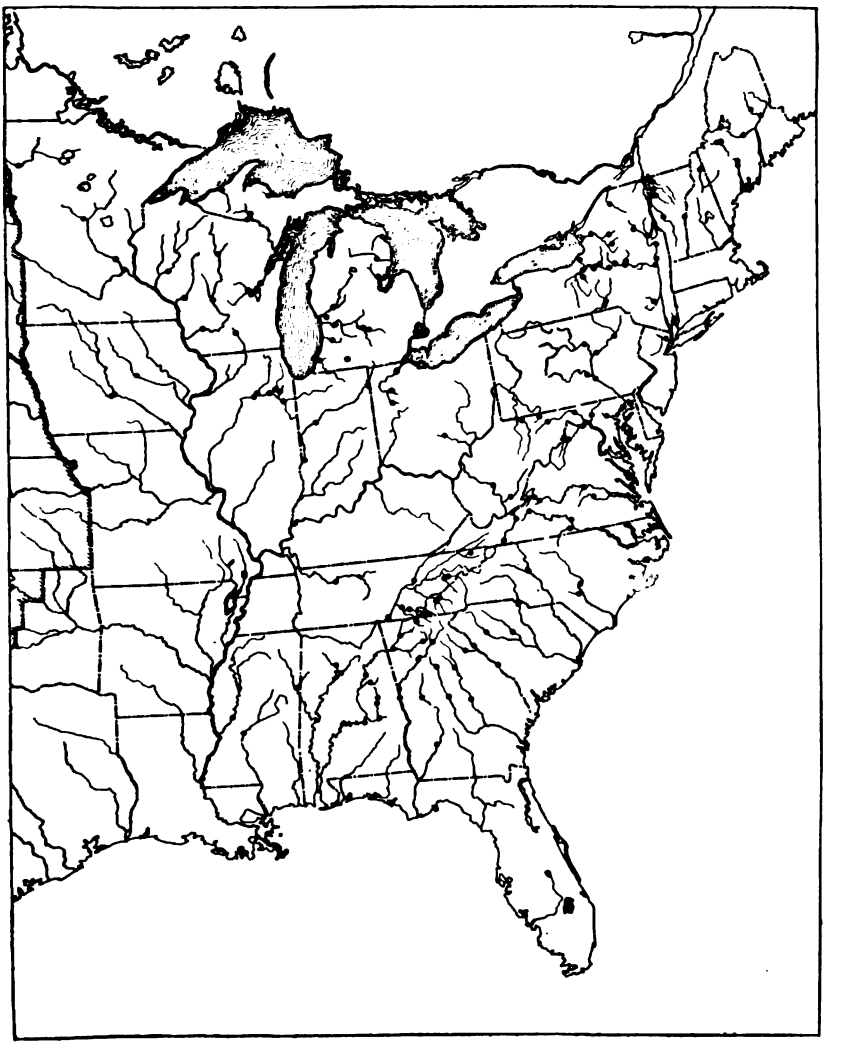

FIG. 2.—Location of river stations in eastern half of United States, 1902-3.

1899. Water-Supply Papers Nos. 35 to 39, inclusive; Part IV of the Twenty-first Annual Report.

1900. Water-Supply Papers Nos. 47 to 52, inclusive; Part IV of the Twenty-second Annual Report.

1901. Water-Supply Papers Nos. 65, 66, and 75.

1902. Water-Supply Papers Nos. 82 and 85, inclusive.

ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers and engineers. Acknowledgment is due to each of these persons, and thanks are extended to other persons and corporations who have assisted local hydrographers or who have cooperated in any way, either by furnishing records or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Colorado.—Resident hydrographer, A. L. Fellows, assisted by M. C. Hinderlider. Acknowledgments are also due to the following individuals and corporations for assistance rendered and data furnished: Hon. A. J. McCune, State engineer of Colorado; Hon. J. J. Armstrong, E. R. Chew, and A. F. Reeves, superintendents of irrigation; L. H. Dickson and T. J. Burrows, water commissioners; also to other water commissioners who have given assistance from time to time.

Transportation has been furnished by the Denver and Rio Grande, Atchison, Topeka and Santa Fe, Colorado and Southern, Union Pacific, and Rio Grande Southern railroads.

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WESTERN MISSISSIPPI RIVER DRAINAGE.

For convenience in arrangement, the stations from which the Geological Survey has obtained data during 1902, and which are located on rivers tributary either directly or indirectly to the Mississippi River from the West, have been grouped under Missouri, Platte, Kansas, Arkansas, and Red River drainage basins. These are arranged in the report in this order.

MISSOURI RIVER DRAINAGE BASIN.

The Missouri River is formed by the junction of the Jefferson, Madison, and Gallatin rivers at Three Forks, Mont. Of its tributaries, the Marais des Cygnes River rises in the eastern part of Kansas, flows east, and, as Osage River, enters the Missouri below Jefferson City, Mo. The Big Sioux River drains the extreme eastern part of South Dakota and flows south into the Missouri at Sioux City, Iowa. The Niobrara River drains the extreme northern part of Nebraska and flows east into the Missouri at Niobrara, Nebr. The Yellowstone River has its source in a lake of the same name in Yellowstone National Park, from which it takes a general northeasterly course and flows into the Missouri near the Montana-North Dakota boundary. Its principal tributaries are the Powder River, of which Clear Creek and Piney Creek in Wyoming are small tributaries near its headwaters, and the Big Horn, which drains northeastern Wyoming, and of which the Shoshone is a tributary. The Milk River rises on the divide in the northwestern part of Montana, flows northeast into Canada and then, with a general easterly course, flows back into Montana, emptying into the Missouri in the northeastern part of the State. The Musselshell River rises in Meagher County, in south central Montana, flows east, then north into the Missouri, about 100 miles above the mouth of Milk River. The Marias River rises on the divide in the northwestern part of Montana and flows east into the Missouri. Two Medicine Creek is a tributary near its headwaters. West Gallatin River, the longest fork of the Gallatin, rises in Yellowstone Park and flows north to its junction at Three Forks, Mont., with the Madison and Jefferson Rivers. Middle Creek is a small tributary of the East Gallatin River. The Madison River rises in Yellowstone Park and flows north parallel to the West Gallatin. The Jefferson River is

formed by the Beaverhead and Big Hole rivers. Its tributaries drain extreme southwestern Montana. The following is a list of the stations in the Missouri River drainage basin:

Marais des Cygnes River at Ottawa, Kans.
Big Sioux River near Watertown, S. Dak.
Niobrara River at Niobrara, Nebr.
Niobrara River at Valentine, Nebr.
Clear Creek at Buffalo, Wyo.
Piney Creek at Kearney, Wyo.
Shoshone River at Cody, Wyo.
Big Horn River near Thermopolis, Wyo.
Yellowstone River near Livingston, Mont.
Milk River at Malta, Mont.
Milk River at Havre, Mont.
Musselshell River at Shawmut, Mont.
Marias River near Shelby, Mont.
Two Medicine Creek at Midvale, Mont.
Missouri River at Cascade, Mont.
Missouri River at Townsend, Mont.
Gallatin River at Logan, Mont.
West Gallatin River near Salesville, Mont.
Middle Creek near Bozeman, Mont.
Madison River near Norris, near Redbluff, Mont.
Jefferson River at Sappington, Mont.

MARAIS DES CYGNES RIVER AT OTTAWA, KANS.

This station was established August 26, 1902, by W. G. Russell, and is located on the highway bridge near the center of the town of Ottawa, Kans. The gage is of the usual wire type, with the scale bar graduated to feet and tenths, and spiked to the bridge floor. The initial point for sounding is on the right bank: The channel both above and below the station is straight and the current quite swift. Both the right and left banks are high and the bed of the stream is rocky. The gage is read daily by W. H. Blacksten.

The following discharge measurements were made during 1902:

August 26: Gage height, 3.60 feet; discharge, 2,080 second-feet.
September 25: Gage height, 5.40 feet; discharge, 3,390 second-feet.
November 22: Gage height, 2.20 feet; discharge, 417 second-feet.

Daily gage height, in feet, of Marais des Cygnes River at Ottawa, Kans.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1		13.50	4.00	1.90	2.50	17		1.80	2.20	2.70	2.30
2		9.15	2.60	1.90	2.30	18		1.80	2.10	2.40	2.20
3		3.20	2.40	1.90	2.50	19		1.70	2.10	2.40	2.10
4		2.40	13.70	2.00	4.70	20		1.80	2.00	2.30	4.80
5		2.20	22.25	2.40	3.00	21		1.80	2.00	2.20	11.60
6		6.30	22.30	2.40	2.40	22		2.90	2.00	2.20	7.60
7		15.90	16.20	2.20	2.30	23		7.00	2.00	2.20	3.50
8		9.60	3.30	2.10	2.20	24		12.75	2.00	2.20	2.90
9		2.90	2.80	2.00	2.20	25		7.20	2.00	2.40	2.50
10		2.30	2.60	2.00	2.20	26	3.60	3.50	2.00	2.40	2.40
11		2.10	2.50	2.00	2.10	27	2.80	2.70	1.90	2.30	2.40
12		2.10	2.40	1.90	2.30	28	2.50	2.40	1.90	2.20	2.30
13		2.00	2.40	2.00	2.30	29	2.30	2.20	1.90	2.10	2.30
14		2.00	2.30	2.00	2.30	30	2.20	4.50	1.90	2.10	2.20
15		1.90	2.20	3.70	2.20	31	7.45		1.90		2.20
16		1.90	2.20	3.40	2.20						

BIG SIOUX RIVER NEAR WATERTOWN, S. DAK.

Big Sioux River rises in Grant County, S. Dak., about 30 miles north of Watertown. Its principal headwaters drain lands constituting part of the Sisseton and Wahpeton Indian Reservation. Its general course is southeast, and it empties into Missouri River near Sioux City, Iowa. The river is of interest on account of its water powers, a number of which have been developed, principally at Flandreau, Dell Rapids, and Sioux Falls, S. Dak., and at Akron, Iowa.

Lake Poinsett, which lies almost wholly in Hamlin County, S. Dak., has its outlet in Big Sioux River near Dempster, a short distance above Estelline. Immediately below the outlet of the lake a dam has been constructed on the Big Sioux to maintain the level of the lake within certain limits.

The gaging station was established by O. V. P. Stout, the gage being put in September 15, 1900, by George W. Carpenter, county surveyor for Codington County. It is located on the farm of L. E. Spicer, about 4 miles above Watertown. The gage consists of an inclined rod securely fastened on the right bank of the stream. The observer is L. E. Spicer. During 1902 the following discharge measurements were made by A. B. Crane.

May 24: Gage height, 1.42 feet; discharge, 22 second-feet.
July 15: Gage height, 0.76 foot; discharge 2.3 second-feet.
November 15: Gage height 0.82 foot; discharge, 2.7 second-feet.

Daily gage height, in feet, of Big Sioux River at Watertown, S. Dak.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.							
1		1.15	0.88	0.70	0.91		
2							0.80
3		1.15		.70	.90	0.70	
4			.88				.70
5				.70		.70	
6		1.15	.88		.80		
7							.80
8		1.15	.85	.70	.70		
9						.73	.80
10		1.13		.70	.70		
11			.83				
12				.70		.70	.70
13		1.00	.80		.70		
14					.70	.70	.80
15		.90	.75	.72			
16					.70		.80
17		.85		.80		.60	
18			.75				.83
19				.80	.68	.69	
20		.83	.73				
21					.68	.68	.74
22		.83	.73	.83			
23					.70		.84
24		.85		.80		.68	
25	1.30		.70				.85
26				.80	.72	.78	
27	1.25	1.00	.70				
28					.73	.80	.85
29		.95	.70	.80			(a)
30	1.15				.72		
31						.80	

a Observations discontinued November 28 on account of ice.

NIOBRARA RIVER AT NIOBRARA, NEBR.

This station was established May 11, 1902, by J. C. Stevens. It is located at the wooden highway bridge 1 mile southwest of the city of Niobrara. The gage is of the usual wire type, graduated to feet and half-tenths. It is read daily by Miner Thompson, who lives near by. The measurements are taken from the bridge. The initial point of soundings is on the east end of the bridge on the upstream side. The channel is straight for a considerable distance both above and below the station. The banks are low, but not liable to overflow. The bed of the stream is sandy and shifting. The main channel seems to be changing from the right to the left bank. The zero-mark of the gage is 6.8 feet east of the face of the fourth floor beam from the west end of the bridge. From the index on the wire to the bottom of the sash weight is 19 feet. When the gage reads zero the water is

12.49 feet below the top of the face plate on the south pier at the west end of the bridge.

Discharge measurements of Niobrara River at Niobrara, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
May 11	J. C. Stevens	2.55	1,637
July 6	do	2.85	2,021
July 25	do	2.00	1,401
August 21	do	2.10	1,106
September 28	do	1.90	2,201

Daily gage height, in feet, of Niobrara River at Niobrara, Nebr.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1902.						
1		2.60	2.70	2.70	2.60	2.40
2		2.50	2.90	2.65	2.50	2.40
3		2.50	2.95	2.65	2.50	2.40
4		2.55	2.90	2.60	2.50	2.30
5		2.70	2.80	2.60	2.45	2.30
6		2.60	2.80	2.55	2.45	2.30
7		2.60	2.70	2.55	2.50	2.25
8		2.55	2.70	2.55	2.45	2.20
9		2.70	2.75	2.60	2.40	2.20
10		2.60	2.67	2.60	2.45	2.20
11	2.55	2.50	2.60	2.70	2.40	2.10
12	2.57	2.75	2.60	2.60	2.35	2.10
13	2.57	2.60	2.60	2.55	2.40	2.10
14	2.70	2.60	2.65	2.50	2.35	2.10
15	2.70	2.60	2.60	2.70	2.30	2.05
16	2.75	2.65	2.60	2.70	2.20	2.00
17	2.57	2.75	2.60	2.75	2.30	2.10
18	2.67	2.70	2.60	2.80	2.20	1.90
19	2.80	2.65	2.65	2.85	2.20	1.90
20	2.90	2.65	2.60	2.75	2.50	2.00
21	3.00	2.75	2.60	2.70	2.90	2.00
22	2.90	2.80	2.60	2.80	2.80	1.90
23	2.57	2.80	2.55	2.70	2.80	1.90
24	2.45	2.60	2.60	2.60	2.60	1.90
25	2.40	2.60	2.65	2.75	2.60	1.90
26	2.50	2.70	2.75	2.90	2.50	(a)
27	2.50	2.85	2.70	2.75	2.50	.....
28	2.60	2.70	2.70	2.65	2.50	.....
29	2.55	2.80	2.70	2.60	2.45	.....
30	2.50	2.75	2.70	2.55	2.40	.....
31	2.45	.....	2.70	2.60	.....	.....

a Observations discontinued October 25, on account of ice.

NIOBRARA RIVER AT VALENTINE, NEBR.

A gaging station was established July 22, 1897, by O. V. P. Stout, and was known as the Fort Niobrara station. It was about three-quarters of a mile southwest from Fort Niobrara and about 3 miles east of Valentine, Nebr. The original gage was an oak rod 2 by 4 inches, graduated to tenths of a foot, and fastened in a vertical position by lag screws to a plumb post in the trestle bent which serves as the west pier of the military bridge near Fort Niobrara. The zero of the gage was 9.08 feet below the top of the short cap, at the shoe of the north truss at the west end of the bridge; it was also 8.09 feet below the top of the north end of the long pile cap, below the cap above noted; and also 9.17 feet lower than the top of the west side of the iron cap of the north cylinder of the center pier of the bridge. This station was afterwards discontinued, but was resumed on April 26, 1899, when a rod was located 195 feet downstream from the wagon bridge near Fort Niobrara. The rod was solidly bedded on cross-ties and well fastened with bridge spikes. It was a new 3 by 4 inch oak rod 10 feet long, and was placed on the left bank of the stream. Bench mark No. 1 was the top of a large spike driven in the top of a 2 by 4 inch timber which was set 4 feet in the ground and 12 feet west of the rod, and was 5.63 feet above gage datum. Bench mark No. 2 was the top of the short cap at shoe of truss at west end of the bridge, downstream side, and was 9.98 feet above the zero of the gage. Bench mark No. 3 was the top of the plate of the center pier of the bridge, downstream side, and was 10.03 feet above gage datum. Thomas Dillon, mail carrier between Valentine and Fort Niobrara, was the observer. On June 26, 1901, it was reestablished at the Borman bridge, which is about 3 miles upstream from the military bridge. The gage is of the wire and weight type, gage heights being marked by staples on the bridge rail. The zero of the gage is 12 feet below the top of the bridge floor.

Discharge measurements of Niobrara River at Valentine, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
March 22	J. C. Stevens	1.66	971
April 12	do	1.50	784
June 15	do	1.30	585
July 4	do	1.60	800
July 20	do	1.40	727
August 20	do	1.40	681
September 26	do	1.55	733
November 13	do	1.60	764

Daily gage height, in feet, of Niobrara River at Valentine, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.										
1	.....	1.58	1.63	1.50	8.10	1.31	1.40	1.43	1.58	1.55
2	.....	1.61	1.65	1.42	1.95	1.32	1.38	1.47	1.64	1.46
3	.....	1.64	1.60	1.44	1.73	1.38	1.30	1.42	1.53	1.16
4	.....	1.70	1.58	1.45	1.56	1.31	1.27	1.44	1.50	1.40
5	.....	1.68	1.65	1.54	1.58	1.42	1.28	1.47	1.57	1.48
6	.....	1.75	1.53	1.55	1.38	1.38	1.30	1.45	1.55	1.55
7	.....	1.50	1.47	1.44	1.25	1.31	1.27	1.44	1.54	(a)
8	.....	1.58	1.56	1.58	1.90	1.43	1.41	1.45	1.58	.....
9	(a)	1 54	1.60	1.42	1.38	1.48	1.28	1.46	1.54	.....
10	1.78	1.55	1.54	1.40	1.32	1.40	1.26	1.51	1.52	.....
11	1.80	1.44	1.52	1.42	1.32	1.24	1.33	1.53	1.50	.....
12	1.75	1.54	1.64	1.50	1.36	1.20	1,32	1.55	1.56	.....
13	1.79	1.58	1.57	1.48	1.27	1.36	1.29	1.52	1.60	.....
14	1.67	1.60	1.55	1.40	1.32	1.38	1.37	1.49	1.58	.....
15	1.65	1.54	1.63	1.28	1.26	1.39	1.33	1.48	1.56	.....
16	1.40	1.64	1.47	1.42	1.25	1.38	1.35	1.55	1.62	.....
17	1.33	1.72	1.52	1.47	1.26	1.44	1.34	1.52	1.56	.....
18	1.60	1.66	1.49	1.34	1.40	1.37	1.45	1.48	1.61	.....
19	1.95	1.58	1.83	1.52	1.42	1.38	1.40	1.50	1.54	.....
20	1.85	1.56	1.78	1.47	1.40	1.34	1.48	1.49	1.57	.....
21	2.05	1.47	1.51	1.36	1.34	1.45	1.45	1.48	1.50	.....
22	1.66	1.74	1.45	1.80	1.32	1.43	1.47	1.51	1.56	.....
23	1.75	1.69	1.51	1.32	1.37	1.34	1.33	1.55	1.52	.....
24	1.98	1.52	1.46	1.36	1.41	1.43	1.37	1 50	1.53	.....
25	1.90	1.80	1.44	1.33	1.32	1.62	1.48	1.51	1.60	.....
26	1.96	1.75	1.42	1.34	1.38	1.45	1.59	1.56	1.51	.....
27	1.93	1.54	1.48	1.37	1.35	1.31	1.53	1.53	1.56	.....
28	1.89	1.72	1.37	1.46	1.32	1.38	1.45	1.52	1.53	.....
29	1.83	1.58	1.40	1.95	1.34	1.40	1.57	1.51	1.46	.....
30	1.97	1.65	1.33	2.10	1.45	1.43	1.42	1.54	1.48	.....
31	1.85	.....	1.42	.....	1.36	1.52	.....	1.50	.....	.....

a Ice interfered with observations from January 1 to March 9 and from December 6 to 31.

Rating table for Niobrara River at Valentine, Nebr., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	475	1.3	580	1.6	865	1.9	1,330
1.1	490	1.4	655	1.7	1,000	2.0	1,525
1.2	525	1.5	750	1.8	1,155		

Estimated monthly discharge of the Niobrara River at Valentine, Nebr.

[Drainage area, 6,070 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March, 22 days			1,169	51,011	0.19	0.16
April	1,155	700	896	53,310	.15	.17
May	1,240	615	802	49,305	.13	.15
June	1,740	580	740	44,030	.12	.13
July	4,260	580	805	49,490	.13	.15
August	865	525	653	40,145	.11	.13
September	865	550	649	38,614	.11	.12
October	805	655	745	45,805	.12	.14
November	930	700	807	48,015	.13	.15

CLEAR CREEK AT BUFFALO, WYO.

This station was established October 24, 1902, by Jeremiah Ahern. It is located at the highway bridge in the town of Buffalo, Johnson County, Wyo. The gage is a plain staff graduated to feet and tenths, spiked to the pier at the northwest end of the bridge. The initial point for sounding is on the left bank. Measurements are made from the bridge. The channel is straight both above and below the station. Both banks are high and rocky. The bed of the stream is also rocky. The gage is read daily by P. A. Gatchell. The bench mark is U. S. G. S. B. M. at the court-house, marked "SHER 4635." Elevation 4,635.033 feet. The elevation of the gage as determined from this bench mark is 4,605.766 feet.

Daily gage height, in feet, of Clear Creek at Buffalo, Wyo.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.			1902.		
1		0.90	9		1.00	17	0.70	1.00	25	0.85	0.80
2		.90	10		.80	18	.68	1.00	26	.90	.80
3		.80	11		.80	19	.70	.90	27	1.00	.75
4		.80	12		.90	20	.80	.85	28	1.00	.90
5		.80	13		.90	21	.70	.90	29	1.20	1.20
6		.80	14		.90	22	.70	.85	30	1.00	1.30
7		.90	15		1.10	23	.70	.85	31		1.50
8		.90	16	0.65	1.60	24	.80	.85			

PINEY CREEK AT KEARNEY, WYO.

This station was established September 6, 1902, by Jeremiah Ahern. It is located at the highway bridge at Kearney, Johnson County, Wyo., which is on the stage route between Sheridan and Buffalo, 24 miles from Sheridan. The gage is a vertical staff graduated to feet and tenths and spiked to the abutment of the bridge. It is read daily by R. D. Noyce. The initial point for sounding is on the right bank. Discharge measurements are taken from the bridge. The channel is straight for 600 feet above and 200 feet below the station. The left bank is high, and liable to overflow at extreme high water. The right bank is high and does not overflow. The bed of the stream is gravel. The bench mark is the U. S. G. S. bench mark at Geier's Ranch, about 600 feet from the gage. It is marked "SHER 4662." Elevation 4,661.767 feet. The elevation of the zero of the gage as referred to this bench mark is 4,645.963 feet.

The following discharge measurement was made in 1902, by J. Ahern.

September 6: Gage height, 1.41 feet; discharge, 21 second-feet.

Daily gage height, in feet, of Piney Creek at Kearney, Wyo.

Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.	Day.	Sept.	Oct.
1902.			1902.			1902.			1902.		
1		1.47	9	1.43	1.41	17	1.48	1.39	25	1.42	1.44
2		1.43	10	1.43	1.40	18	1.49	1.39	23	1.47	
3		1.43	11	1.43	1.41	19	1.48	1.38	27	1.60	
4		1.42	12	1.43	1.40	20	1.47	1.39	28	1.43	
5		1.41	13	1.43	1.39	21	1.48	1.39	29	1.50	
6		1.41	14	1.43	1.40	22	1.46	1.40	30	1.40	
7	1.45	1.40	15	1.43	1.40	23	1.45	1.55			
8	1.43	1.42	16	1.48	1.40	24	1.43	1.46			

SHOSHONE RIVER AT CODY, WYO.

This station was established April 26, 1902, by A. J. Parshall. It is located at the wagon bridge 1 mile northwest of Cody, Wyo. The gage is a plain staff graduated to one-half tenths and is fastened to the bridge, from which discharge measurements are made. The initial point for sounding is on the left bank. The channel is straight both above and below the station. The current is swift. The right bank is low and subject to overflow. The left bank is high and does not overflow. The bed of the stream is gravel and rock. The bench mark is a bolt in the bridge sleeper 1.15 feet above the 12-foot mark on the gage. It is indicated by a cross. The observer is W. J. Kissick, who reads the gage twice daily.

During 1902 the following discharge measurements were made by A. J. Parshall:

April 26: Gage height, 2.40 feet; discharge, 538 second-feet.
June 7: Gage height, 4.80 feet; discharge, 4,352 second-feet.
July 17: Gage height, 4.10 feet; discharge, 2,812 second-feet.
July 31: Gage height, 3.65 feet; discharge, 2,039 second-feet.
December 8: Gage height, 2.00 feet; discharge, 270 second-feet.

Daily gage height, in feet, of Shoshone River at Cody, Wyo.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1902.						
1	2.75	5.50	4.15	4.00	2.50	2.50
2	3.00	5.00	4.45	4.00	2.50	2.50
3	2.55	4.50	4.65	4.00	2.50	2.50
4	2.50	4.50	4.45	3.45	2.50	2.50
5	2.50	5.00	4.00	3.40	2.50	2.50
6	2.60	5.00	4.05	3.50	2.50	2.50
7	3.00	4.80	4.00	3.45	2.50	2.50
8	3.55	5.60	4.00	3.50	2.50	2.50
9	4.00	6.00	4.00	3.50	2.50	2.50
10	4.20	6.60	4.05	3.15	2.50	2.50
11	4.40	6.60	4.20	3.00	2.50	2.50
12	4.15	6.30	4.50	3.00	2.50	2.50
13	4.30	6.30	4.50	3.00	2.50	2.50
14	4.50	6.00	4.45	3.00	2.50	2.50
15	4.90	5.40	4.45	3.00	2.50	2.50
16	4.50	5.00	4.25	3.00	2.50	2.50
17	4.35	5.00	4.25	3.00	2.50	2.50
18	4.40	5.00	4.25	3.00	2.50	2.50
19	4.10	4.70	4.35	3.00	2.50	2.50
20	3.65	4.50	4.00	3.00	2.50	2.50
21	3.50	5.00	4.00	3.00	2.50	2.50
22	3.50	4.90	4.10	3.00	2.50	2.50
23	3.50	5.25	4.10	3.00	2.50	2.50
24	3.50	5.25	4.00	3.00	2.50	2.50
25	3.50	5.25	4.00	3.00	2.50	2.50
26	3.90	5.25	4.00	3.00	2.50	2.50
27	4.75	5.00	4.00	3.00	2.50	2.50
28	5.25	4.85	4.10	3.00	2.50	2.50
29	5.25	4.50	4.20	3.00	2.50	2.50
30	5.50	4.50	4.00	3.00	2.50	2.50
31	5.75	.....	4.00	2.50	.....	2.50

Rating table for Shoshone River at Cody, Wyo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.5	30	2.8	860	4.1	2,920	5.4	5,585
1.6	70	2.9	960	4.2	3,125	5.5	5,790
1.7	110	3.0	1,070	4.3	3,330	5.6	5,995
1.8	160	3.1	1,190	4.4	3,535	5.7	6,200
1.9	210	3.2	1,320	4.5	3,740	5.8	6,405
2.0	270	3.3	1,460	4.6	3,945	5.9	6,610
2.1	335	3.4	1,610	4.7	4,150	6.0	6,815
2.2	400	3.5	1,770	4.8	4,355	6.1	7,020
2.3	470	3.6	1,940	4.9	4,560	6.2	7,225
2.4	540	3.7	2,120	5.0	4,765	6.3	7,430
2.5	615	3.8	2,310	5.1	4,970	6.4	7,635
2.6	690	3.9	2,510	5.2	5,175	6.5	7,840
2.7	770	4.0	2,715	5.3	5,380		

Estimated monthly discharge of Shoshone River at Cody, Wyo.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
May	6,300	615	2,752	168,904
June	8,045	3,740	5,246	311,632
July	4,045	2,715	2,755	169,112
August	2,715	615	1,346	82,762
September	615	615	615	37,749
October	615	615	615	37,749

BIGHORN RIVER NEAR THERMOPOLIS, WYO.

This station, which was established by A. J. Parshall on May 28, 1900, was located about a half mile northeast of Thermopolis, at the ferry crossing the river. The gage, which consists of a horizontal rod extending out over the water, is fastened to a post set firmly in the bank. On the horizontal stick is attached the wire gage by means of which the heights of the river are recorded. The bench mark was the head of a nail in a stick driven in the ground 1 foot south of the post to which the gage rod is fastened and 2.58 feet below the top of the gage frame. The bench mark has been destroyed. A new gage, whose relative heights are the same as those of the gage of 1901, was painted on a pier on the right bank in 1903. This gage is reached only by the

water when it is at a height of 3 feet above datum. It will enable the observer to read heights of high water more accurately than can be done upon the gage rod which is in the center of the stream and is exposed to the force of the current, causing a rise and fall of several inches on the rod. Discharge measurements were first made from a ferryboat, but, beginning with 1902, they have been made from the bridge which was recently erected. The channel is straight above and below the station. Both banks are high and not subject to overflow. The bed of the stream is of gravel and shifts during extreme high water. In 1901 a gage was painted upon one of the lower piers of the new State bridge over the river, 400 or 500 feet upstream from the former station. The relative heights on the rod remained as before, the same bench mark being used. During 1902 the following discharge measurements were made by A. J. Parshall:

June 11: Gage height. 4.70 feet; discharge, 9,080 second-feet.
June 14: Gage height, 4.40 feet; discharge, 8,391 second-feet.
June 16: Gage height, 3.60 feet; discharge, 6,334 second-feet.

Daily gage height, in feet, of Bighorn River near Thermopolis, Wyo.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1902.					1902.				
1	2.40	2.80	2.70	0.90	17	3.40	1.50	2.10	0.70
2	2.60	2.80	2.60	.80	18	3.40	1.50	2.10	.60
3	2.70	2.70	2.60	.80	19	3.30	1.50	2.00	.60
4	2.70	2.60	2.60	.80	20	2.90	1.40	1.90	.60
5	2.60	2.50	2.50	.70	21	2.40	1.40	1.80	.60
6	2.40	2.30	2.50	.70	22	2.50	1.40	1.70	.50
7	3.40	2.10	2.40	.60	23	2.40	1.30	1.60	.50
8	3.70	2.00	2.30	.60	24	2.30	1.30	1.60	1.00
9	4.20	2.00	2.30	.90	25	2.20	1.40	1.50	1.00
10	4.20	1.90	2.20	1.00	26	2.30	2.50	1.40	.90
11	4.70	1.80	2.20	1.20	27	2.20	3.00	1.20	.90
12	5.00	1.80	2.30	1.00	28	2.10	3.00	1.10	.80
13	4.60	1.70	2.30	.90	29	2.30	3.00	1.00	.60
14	4.40	1.70	2.20	.80	30	2.40	2.90	.90	.50
15	4.00	1.60	2.10	.80	31		2.80	.90	
16	3.60	1.50	2.10	.70					

YELLOWSTONE RIVER NEAR LIVINGSTON, MONT.

The gaging station is located at the highway bridge over the Yellowstone River, 5 miles south of Livingston, Mont., at the mouth of the canyon. It was established May 2, 1897, a vertical rod fastened to the face of the pier being first used. A wire gage was afterwards established. Length of cable 18.30 feet; pulley distance, 0.58 foot. The bench mark is the head of the 2-inch nut on the center pin at the foot of the end diagonal of the truss, east pier, upper side, and is 13.44 feet above datum.

A new bench mark was determined in 1899. It was the top of the end plate of the bridge at the upper side of the east end, at an elevation of 14.20 feet above zero of gage. On January 1, 1903, the gage (and the datum) were lowered 3.00 feet, making all subsequent readings 3 feet greater. The elevation of bench mark also reads 17.20 feet, instead of 14.20 feet. The slope of the water surface at the gaging station was found to be 0.146 feet in 200 feet on August 29, 1899. The left bank is high and will not overflow. The right bank is low, and during floods a part of the water escapes through a slough on that side, and has to be measured separately. The observer is Thomas S. Carter, rancher.

During 1902 the following discharge measurements were made by H. B. Waters:

May 1: Gage height, −0.82 foot; discharge, 1,604 second-feet.
July 16: Gage height, 2.90 feet; discharge, 8,359 second-feet.
August 23: Gage height, 0.23 foot; discharge, 3,081 second-feet.

Daily gage height, in feet, of Yellowstone River near Livingston, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	−1.80	(a)	−1.20	−1.20	−0.75	5.15	3.50	1.52	−0.05	−0.65	−1.05	1.30
2	−1.30	(a)	−1.15	−1.15	−.80	4.20	3.50	1.42	−.10	−.70	−1.05	−1.30
3	−1.00	−1.60	−1.20	−1.15	−.80	3.70	3.77	1.32	−.10	−.70	−1.10	−1.40
4	−.90	−1.50	−1.20	−1.15	−.80	3.60	3.57	1.20	−.15	−.70	−1.10	−1.40
5	−1.00	−1.40	−1.25	−1.15	−.75	3.90	3.50	1.15	−.20	−.75	−1.25	−1.30
6	−1.10	−1.40	−1.20	−1.10	−.75	3.90	3.30	1.05	−.20	−.75	−1.30	−1.40
7	−1.00	−1.40	−1.20	−1.10	−.45	3.90	3.20	1.00	−.25	−.75	−1.20	(a)
8	−1.00	−1.40	−1.20	−1.10	−.15	4.25	3.05	.95	−.25	−.80	−1.05	−1.60
9	−1.00	(a)	−1.25	−1.15	.75	5.20	2.92	.90	−.30	−.80	1.05	−1.30
10	−1.00	−1.20	−1.20	−1.15	1.38	5.90	2.90	.85	−.30	−.80	1.05	−1.30
11	−1.10	−1.10	−1.20	−1.12	1.73	6.05	2.90	.80	−.35	−.80	−1.00	−1.40
12	(a)	−1.10	−1.20	−1.12	1.98	5.80	2.97	.80	−.40	.80	−1.00	−1.40
13	−1.30	−1.10	−1.20	−1.15	2.70	5.50	3.00	.80	−.45	−.85	−1.00	−1.30
14	−1.30	−1.20	−1.30	−1.15	3.03	5.85	3.00	.75	−.45	−.85	−1.00	(a)
15	−1.20	−1.20	−1.25	−1.15	3.65	4.65	2.90	.75	−.50	−.85	−1.05	−1.60
16	−1.30	−1.00	−1.20	−1.10	3.28	4.32	2.80	.70	−.50	−.90	−1.10	−1.70
17	−1.30	−.90	−1.20	−1.05	3.35	4.07	2.77	.70	−.50	−.90	−1.10	−1.60
18	−1.10	−1.00	−1.20	−.95	2.88	4.00	2.62	.70	−.50	−.90	−1.10	−1.60
19	−1.15	−1.00	−1.20	−.80	2.43	3.85	2.45	.65	−.50	−.95	−1.15	−1.50
20	−1.20	−1.20	−1.20	−.35	1.93	3.67	2.35	.60	.55	−.95	−1.15	−1.40
21	−1.30	−1.20	−1.20	−.60	1.78	3.77	2.30	.50	−.55	−.95	−1.25	−1.40
22	−1.20	−1.20	−1.20	−.90	1.50	3.90	2.28	.40	−.60	−.95	−1.35	−1.40
23	−1.50	−1.20	−1.20	−.60	1.43	4.05	2.20	.35	−.60	−1.00	−1.30	−1.30
24	(a)	−1.20	−1.20	−.70	1.55	4.13	2.15	.30	−.60	−1.00	−1.25	−1.40
25	(a)	−1.20	−1.20	−.80	2.13	4.00	2.10	.25	−.60	−1.00	−1.20	−1.20
26	(a)	−1.20	−1.15	−.90	2.68	4.03	2.02	.20	−.65	−1.00	−1.30	−1.10
27	(a)	−1.20	−1.15	−.90	3.58	3.85	1.92	.15	−.65	−1.00	−1.35	−1.30
28	(a)	−1.20	−1.20	−.90	4.25	3.90	1.80	.10	.65	−1.00	−1.35	(a)
29	(a)	.....	−1.35	−.85	4.55	3.55	1.75	.05	−.65	−1.00	1.35	−1.50
30	(a)	.....	−1.35	−.80	5.10	3.60	1.70	.00	−.65	−1.00	−1.45	−1.50
31	a−1.60	.....	−1.30	.....	5.40	.....	1.62	.00	.....	−1.05	.....	−1.50

a River frozen at gage.

Rating table for Yellowstone River near Livingston, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−1.6	1,000	0.4	3,445	2.4	7,375	4.4	11,350
−1.4	1,135	.6	3,840	2.6	7,765	4.6	11,750
−1.2	1,280	.8	4,225	2.8	8,155	4.8	12,150
−1.0	1,440	1.0	4,620	3.0	8,545	5.0	12,550
− .8	1,640	1.2	5,010	3.2	8,950	5.2	12,950
− .6	1,825	1.4	5,395	3.4	9,350	5.4	13,350
− .4	2,070	1.6	5,790	3.6	9,750	5.6	13,750
− .2	2,350	1.8	6,195	3.8	10,150	5.8	14,150
.0	2,680	2.0	6,590	4.0	10,550	6.0	14,550
.2	3,050	2.2	6,985	4.2	10,950	6.2	14,950

Estimated monthly discharge of Yellowstone River near Livingston, Mont.

[Drainage area, 3,580 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean		Second-feet per square mile.	Depth in inches.
1902.						
January	1,550	1,000	1,242	76,368	0.35	0.40
February	1,550	1,000	1,254	69,644	.35	.36
March	1,317	1,170	1,268	77,966	.35	.40
April	2,137	1,280	1,479	88,007	.41	.46
May	13,350	1,640	6,392	393,029	1.79	2.06
June	14,650	9,650	11,230	668,231	3.14	3.50
July	10,050	5,790	7,899	485,691	2.21	2.55
August	5,590	2,680	3,974	244,352	1.11	1.28
September	2,592	1,770	2,053	122,162	.57	.64
October	1,770	1,397	1,564	96,167	.44	.51
November	1,440	1,135	1,309	77,891	.37	.41
December	1,355	960	1,129	69,420	.32	.37
The year	14,650	960	3,402	2,468,928	.95	12.94

MILK RIVER AT MALTA, MONT.

This station was established July 31, 1902, by C. T. Prall. It is located at the highway bridge on the main road one-fourth mile east of Malta, Mont. The gage is of the usual wire type, with the scaleboard graduated to feet and tenths and nailed to the lower

side of the bridge. The length of the gage wire from the pointer to the end of the weight is 28.7 feet. The distance from the zero on the rod to the outside edge of the pulley is 0.5 of a foot. The gage is read twice daily by H. Caselberg. The initial point for sounding is on the right bank. The channel is straight for 700 feet above the station and 250 feet below the station. The banks are not liable to overflow. The bed of the stream is rocky and sandy. The bench mark is a 20-penny wire nail driven just below the gage rod at a gage reading of 5 feet.

Discharge measurements of Milk River at Malta, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
July 31	C. T. Prall	2.50	525
August 21	do	1.80	259
September 10	do	1.40	166
September 25	F. E. Weymouth	1.50	165
October 6	John T. Whistler	1.85	271
October 11	F. E. Weymouth	1.65	198
October 17	Cyrus C. Babb	1.67	174
October 24	John T. Whistler	1.60	171
October 31	George Drummond	1.70	257
November 7	John T. Whistler	1.70	210

Daily gage height, in feet, of Milk River at Malta, Mont.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1902.					1902.				
1	2.30	1.80	1.70	1.60	17	1.70	1.30	1.60	.....
2	2.40	1.70	1.70	1.60	18	1.80	1.30	1.60	.....
3	2.30	1.70	1.70	1.60	19	1.80	1.30	1.60	.....
4	2.20	1.70	1.70	1.60	20	1.70	1.30	1.60	.....
5	2.10	1.70	1.70	1.60	21	1.70	1.30	1.60	.....
6	2.10	1.70	1.70	1.60	22	1.80	1.30	1.60	.....
7	2.10	1.70	1.70	1.60	23	1.70	1.30	1.60	.....
8	2.10	1.60	1.70	1.70	24	1.80	1.30	1.60	.....
9	2.10	1.50	1.70	.....	25	1.80	1.30	1.60	.....
10	2.00	1.50	1.80	.....	26	1.80	1.40	1.60	.....
11	1.95	1.50	1.80	.....	27	1.80	1.40	1.60	.....
12	1.90	1.40	1.60	.....	28	1.70	1.30	1.60	.....
13	1.90	1.30	1.60	.....	29	1.70	1.30	1.60	.....
14	1.90	1.30	1.60	.....	30	1.70	1.40	1.60	.....
15	1.90	1.30	1.60	.....	31	1.70	.....	1.60	.....
16	1.70	1.30	1.60	.....					

Rating table for Milk River at Malta, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	32	2.4	485	4.2	1,187	6.0	1,889
0.8	47	2.6	563	4.4	1,265	6.2	1,967
1.0	68	2.8	641	4.6	1,343	6.4	2,045
1.2	93	3.0	719	4.8	1,421	6.6	2,123
1.4	127	3.2	797	5.0	1,499	6.8	2,201
1.6	173	3.4	875	5.2	1,577	7.0	2,279
1.8	251	3.6	953	5.4	1,655		
2.0	329	3.8	1,031	5.6	1,733		
2.2	407	4.0	1,109	5.8	1,811		

Estimated monthly discharge of Milk River at Malta, Mont.

[Drainage area, 6,744 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
August	485	212	294	18,056	0.04	0.05
September	251	109	143	8,509	.02	.02
October	251	173	189	11,620	.03	.03
November 1 to 8			178	2,822	.03	.01

MILK RIVER AT HAVRE, MONT.

The present station is located at Havre, Mont., and was established by Cyrus C. Babb, May 15, 1898. Measurements of discharge are made from a car and cable of 200-foot span swung across the river a short distance above the gage. The river is subject to violent floods of short duration, and the bed of the river being composed of gravels and clay is liable to change after each freshet.

Discharge measurements of Milk River at Havre, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 11	J. S. Baker	3.50	249
April 19	L. H. Ling	3.10	214
May 19	do	4.00	362
May 22	do	4.90	1,013
May 23	do	7.35	3,363
May 24	do	8.88	5,179
May 27	do	6.60	2,503
July 10	do	7.00	2,341
July 31	do	4.70	573
August 8	do	4.10	387
August 26	do	4.20	427
August 30	do	3.90	269
September 11	do	3.60	192
September 17	do	3.80	240
September 23	do	3.90	226
September 30	do	4.00	229
October 6	do	3.90	206
October 16	do	3.90	208
October 29	do	3.90	206
November 4	L. V. Branch	3.77	205

Daily gage height, in feet, of Milk River at Havre, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1			4.20	2.80	3.10	4.30	4.60	4.70	3.90	4.00	3.90	
2			4.20	2.80	3.20	4.30	4.60	4.60	3.90	3.90	4.00	
3			4.20	2.80	3.20	6.40	5.00	4.30	3.90	3.90	4.00	(a)
4		(a)	4.00	3.60	3.10	7.40	6.50	4.20	3.80	3.90	3.80	
5			3.90	3.50	3.10	8.40	7.50	4.20	3.80	3.90	3.80	
6			3.40	3.40	3.00	8.00	8.00	4.10	3.80	3.90	3.80	
7			3.20	3.10	3.00	8.00	12.10	4.10	3.80	3.90	3.80	
8			3.20	3.10	3.00	6.00	10.50	4.10	3.80	3.90	(a)	(a)
9	a 3.00		3.20	3.10	3.10	5.50	8.00	4.10	3.80	3.80		
10			3.60	3.10	3.10	5.40	7.00	4.10	3.60	3.80		
11			4.30	3.50	3.20	5.20	6.40	4.10	3.60	3.80		
12			4.00	3.70	3.20	5.00	6.00	4.10	3.60	3.90		
13			3.40	3.70	3.20	5.00	6.20	4.10	3.60	3.90	(a)	(a)
14			3.20	3.60	3.20	4.90	6.20	4.10	3.60	3.90		
15		(a)	3.20	3.50	3.20	4.80	6.00	4.10	3.60	3.90		
16			3.20	3.50	3.30	5.20	6.00	4.00	3.80	3.90		
17			3.20	3.30	3.40	5.20	5.50	4.00	3.80	3.90		
18	a 3.00		3.20	3.20	4.00	5.20	5.20	4.00	3.70	3.90	(a)	(a)
19		3.30	3.20	3.10	4.00	5.20	5.00	4.00	3.60	3.90		
20		3.60	3.20	3.00	4.10	5.20	5.20	4.00	3.60	3.90		
21		3.30	3.20	2.90	4.10	5.20	5.20	4.00	3.60	3.90		
22		3.80	3.20	2.90	5.10	5.20	5.00	4.00	3.80	3.90		
23		3.10	3.20	3.00	7.80	5.10	5.20	3.90	3.90	3.90	(a)	(a)
24		3.10	3.40	3.00	10.50	5.10	5.20	3.90	3.90	3.90		
25	a 3.00	3.10	3.50	3.00	11.00	5.00	5.20	4.00	4.00	3.90		
26		3.10	3.60	3.00	7.30	4.90	5.00	4.20	4.00	3.90		
27		3.40	3.60	2.90	6.60	4.80	4.90	4.10	3.90	3.90		
28		3.40	3.50	2.90	5.60	4.80	4.90	4.00	3.90	3.90	(a)	(a)
29			3.20	2.90	5.00	4.60	4.80	4.00	3.90	3.90		
30	a 3.00		2.90	3.00	4.50	4.60	4.70	3.90	4.00	3.90		
31			2.90		4.50		4.70	3.90		3.90		

a Frozen at gage.

Rating table for Milk River at Havre, Mont., for 1902.

FROM JANUARY 1 TO MAY 22.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.6	145	5.0	989	7.4	3,442	9.8	6,259
2.8	161	5.2	1,178	7.6	3,677	10.0	6,494
3.0	180	5.4	1,368	7.8	3,912	10.2	6,729
3.2	200	5.6	1,557	8.0	4,147	10.4	6,964
3.4	222	5.8	1,746	8.2	4,381	10.6	7,199
3.6	250	6.0	1,935	8.4	4,616	10.8	7,433
3.8	288	6.2	2,124	8.6	4,851	11.0	7,668
4.0	335	6.4	2,314	8.8	5,086	11.5	8,255
4.2	412	6.6	2,503	9.0	5,320	12.0	8,842
4.4	519	6.8	2,738	9.2	5,555	12.5	9,429
4.6	630	7.0	2,973	9.4	5,790		
4.8	800	7.2	3,207	9.6	6,025		

Rating table for Milk River at Havre, Mont., for 1902—Continued.

FROM MAY 23 TO DECEMBER 31.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.6	100	3.0	122	3.4	157	3.8	212
2.8	109	3.2	138	3.6	180	4.0	300

[a] Above 4 feet the table is the same as for the fore part of the year.

Estimated monthly discharge of Milk River at Havre, Mont.

[Drainage area 7,300 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	180	180	180	11,068	0.02	0.02
February			[a] 208	11,552	.03	.03
March	465	170	249	15,310	.03	.03
April	268	161	196	11,663	.03	.03
May	7,668	180	1,085	66,714	.15	.17
June	4,616	465	1,479	88,007	.20	.22
July	8,960	630	2,045	125,742	.28	.32
August	710	310	377	23,181	.05	.06
September	335	250	297	17,673	.04	.04
October	335	288	309	18,999	.04	.04
November			[a] 300	17,851	.04	.04
December			[a] 300	18,466	.04	.04
The year	8,960	161	586	426,226	.08	1.04

[a] Frozen; estimated.

MUSSELSHELL RIVER AT SHAWMUT, MONT.

This station was established August 12, 1902, by S. B. Dobbins. It is located about 200 yards west of Shawmut post-office, which is at the home ranch of the Blooming Land and Cattle Company. The gage is a vertical pole, graduated to feet and tenths, and nailed to a stump which overhangs the river. The observer is Dwight Crawford, who reads the gage daily. No bench marks have been established. The barometric elevation at this station is 3,900 feet.

Daily gage height, in feet, of Musselshell River at Shawmut, Mont.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1		0.60	1.00	1.10	1.10	17	0.70	0.70	1.10	1.20	1.30
2		.60	1.00	1.10	1.10	18	.70	.70	1.10	1.20	1.20
3		.60	1.00	1.10	1.10	19	.70	.70	1.10	1.10	1.20
4		.60	1.00	1.20	1.10	20	.70	.80	1.10	1.10	1.20
5		.60	1.00	1.00	1.20	21	.70	.70	1.10	1.00	1.20
6		.50	1.00	1.80	1.20	22	.70	.70	1.10	1.00	1.20
7		.50	1.00	1.10	1.20	23	.70	.70	1.10	1.10	1.20
8		.50	1.00	1.20	1.20	24	.70	.70	1.10	1.20	1.30
9		.50	1.00	1.20	1.20	25	.60	.70	1.10	1.20	1.30
10		.70	1.00	1.20	1.20	26	.60	.70	1.10	1.20	1.30
11		.70	1.10	1.20	1.20	27	.80	.70	1.10	1.20	1.30
12	0.60	.70	1.10	1.20	1.20	28	.70	.80	1.10	1.20	1.40
13	.50	.70	1.10	1.20	1.20	29	.60	.90	1.10	1.20	1.40
14	.50	.70	1.10	1.20	1.20	30	.60	.90	1.20	1.10	1.40
15	.50	.70	1.10	1.20	1.20	31	.60		1.20		1.40
16	.60	.70	1.10	1.20	1.20						

MARIAS RIVER NEAR SHELBY, MONT.

This station was established April 4, 1902, by J. S. Baker. It is located on the highway bridge 7 miles south of Shelby, Mont. The gage is of the usual wire type. The scaleboard is spiked to the downstream face of the bridge and is graduated to feet and tenths. It is read daily by William Mead, who lives about one-half mile southwest of the gage. The right bank is low and liable to overflow. The left bank is high and confined by a row of piles and a plank wall. The bed of the stream is composed of sand and gravel. Above the station the channel is curved. Below the station it is straight. The initial point for sounding is on the left bank at the east edge of the east pier on the lower side of the bridge. Bench mark No. 1 is a rivet head in the footplate at the foot of the batter post on the top of the southeast pier of the bridge. It is marked with black paint, B. M. 17.54. Its elevation above the zero of the gage is 17.54 feet. B. M. No. 2 is a spike in the southwest side of a cottonwood stump 25 feet southeast of the southeast pier. It is marked B. M. 11.27. Its elevation above the zero of the gage is 11.27 feet.

Discharge measurements of Marias River near Shelby, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 4	J. S. Baker	2.05	358
April 4	do	2.05	357
July 8	L. V. Branch	5.95	5,664
July 23	do	3.68	1,658
July 29	C. T. Prall	3.40	1,295
August 15	C. C. Babb	2.80	780
September 19	C. T. Prall	2.40	547
November 3	L. V. Branch	2.16	299

Daily gage height, in feet, of Marias River near Shelby, Mont.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1		2.70	6.50	4.10	3.10	2.40	2.20	2.20	2.30
2		2.70	6.40	5.00	3.10	2.30	2.20	2.20	2.30
3		2.90	6.20	6.40	3.00	2.20	2.20	2.20	2.30
4	2.50	2.70	5.50	11.50	3.00	2.30	2.20	2.20	2.30
5	2.60	2.60	5.20	11.00	3.00	2.40	2.20	2.20	2.30
6	2.40	2.50	5.00	8.50	2.90	2.40	2.20	2.10	2.30
7	2.10	2.60	4.90	6.80	2.80	2.40	2.20	2.20	2.30
8	2.10	2.90	4.80	6.10	2.70	2.30	2.20	2.20	2.30
9	2.00	3.00	4.50	5.60	2.80	2.20	2.20	2.10	2.30
10	2.10	3.30	4.80	5.30	3.00	2.10	2.20	2.20	2.30
11	2.10	3.30	5.10	5.10	2.80	2.20	2.20	2.20	2.30
12	2.10	3.90	5.10	4.90	2.70	2.20	2.20	2.30	2.50
13	2.10	3.90	4.90	4.50	2.50	2.20	2.20	2.70	2.60
14	2.10	3.90	4.60	4.50	2.50	2.20	2.20	2.60	2.60
15	2.20	4.40	4.50	4.50	2.50	2.20	2.20	2.60	2.50
16	1.90	5.70	4.40	4.40	2.40	2.30	2.20	2.50	2.60
17	2.00	5.40	4.50	4.40	2.40	2.20	2.20	2.60	2.50
18	2.00	5.10	4.40	4.10	2.50	2.20	2.20	2.50	2.50
19	2.00	5.10	4.20	4.10	2.20	2.30	2.20	2.50	2.50
20	2.00	4.90	4.20	4.00	2.10	2.20	2.20	2.50	2.60
21	2.50	9.90	4.10	4.00	2.10	2.20	2.20	2.40	2.60
22	2.70	14.50	4.00	3.90	2.30	2.50	2.20	2.50	2.50
23	2.60	9.20	4.10	3.80	2.00	2.40	2.20	2.50	2.50
24	2.50	9.40	3.90	3.60	2.40	2.20	2.20	2.50	2.50
25	2.40	9.00	4.10	3.50	2.60	2.30	2.20	2.40	2.50
26	2.30	6.40	4.10	3.60	2.70	2.20	2.20	2.40	2.60
27	2.40	6.00	4.40	3.60	2.50	2.20	2.20	2.30	2.60
28	2.40	6.50	4.30	3.70	2.50	2.20	2.20	2.30	2.60
29	2.40	6.60	4.20	3.50	2.30	2.30	2.20	2.30	2.40
30	2.60	7.00	4.30	3.30	2.20	2.30	2.20	2.30	2.30
31		6.60		3.30	2.10		2.20		2.30

Rating table for Marias River near Shelby, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	144	3.8	1,871	6.6	6,809	9.4	11,737
1.2	168	4.0	2,223	6.8	7,161	9.6	12,089
1.4	192	4.2	2,575	7.0	7,513	9.8	12,441
1.6	227	4.4	2,927	7.2	7,865	10.0	12,793
1.8	273	4.6	3,279	7.4	8,217	10.2	13,145
2.0	333	4.8	3,631	7.6	8,569	10.4	13,497
2.2	425	5.0	3,983	7.8	8,921	10.6	13,849
2.4	540	5.2	4,355	8.0	9,273	10.8	14,201
2.6	660	5.4	4,707	8.2	9,625	11.0	14,553
2.8	780	5.6	5,059	8.4	9,977	11.2	14,905
3.0	935	5.8	5,401	8.6	10,329	11.4	15,257
3.2	1,105	6.0	5,753	8.8	10,681	11.6	15,609
3.4	1,285	6.2	6,105	9.0	11,033	11.8	15,961
3.6	1,520	6.4	6,457	9.2	11,385	12.0	16,313

Estimated monthly discharge of Marias River near Shelby, Mont.

[Drainage area, 2,610 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 4 to 30			468	25,063	0.18	0.18
May	5,235	600	4,764	292,927	1.83	2.11
June	6,633	2,047	3,469	206,420	1.33	1.48
July	16,313	1,190	3,980	244,721	1.52	1.75
August	1,402	333	654	40,213	.25	.29
September	600	373	463	27,550	.18	.20
October	480	425	425	26,132	.16	.18
November	720	373	518	30,823	.20	.22
December	660	480	563	34,617	.22	.25

TWO MEDICINE CREEK AT MIDVALE, MONT.

This station was established September 17, 1902, by C. C. Babb. It is located 200 yards above the Great Northern Railroad bridge 1 mile from the railroad station at Midvale, Mont. The gage is inclined and graduated so as to give readings of vertical feet and tenths. It is fastened to a tree and stake. The initial point for sounding is on the left bank. The channel is straight for 700 feet above and 300 feet

below the station. The banks are high and rocky. Bench mark No. 1 is a nail in a rock 13.5 feet below the rod. Its elevation is 2.03 feet above the zero of the gage. Bench mark No. 2 is a nail driven in a spruce tree 40 yards north of the rod. Its elevation is 32 feet above the zero of the gage.

The following discharge measurements were made during 1902:

October 15: Gage height, 0.45 foot; discharge, 34 second-feet.
October 15: Gage height, 0.54 foot; discharge, 47 second-feet.

Daily gage height, in feet, of Two Medicine Creek at Midvale, Mont.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1		0.50	0.35	0.70	17		0.45	1.50	0.80
2		.50	.35	.60	18	0.45	.45	1.20	.80
3		.50	.35	.60	19	.50	.45	1.00	.80
4		.50	.30	.60	20	.45	.45	1.00	.80
5		.50	.30	.60	21	.45	.40	.90	.80
6		.45	.30	.60	22	.45	.40	.90	.80
7		.45	.30	.60	23	.40	.40	.80	.80
8		.45	.30	.60	24	.40	.35	.80	.80
9		.45	.30	.70	25	.40	.35	.80	.90
10		.45	.35	.70	26	.45	.35	.70	1.00
11		.50	.40	.80	27	.50	.35	.70	1.00
12		.50	.55	.80	28	.50	.35	.70	1.20
13		.45	.70	.80	29	.50	.35	.70	1.20
14		.45	.90	.80	30	.50	.35	.70	1.20
15		.45	1.20	.80	31		.35		1.20
16		.45	1.50	.80					

MISSOURI RIVER AT CASCADE, MONT.

This station was established July 1, 1902, by W. W. Schlecht. It is located at the highway bridge in the town of Cascade, Mont., about one-fourth of a mile from the railroad. The gage is of the usual wire type, and the scaleboard is graduated to feet and tenths and is fastened to one of the eyebars of the bridge. It is read daily by H. W. Ludwig. The initial point for sounding is on the abutment of the right approach to the bridge. The channel is straight for about 600 feet above the station and 300 feet below. About 300 feet below the station there is an island, on either side of which the river is rapid. There is about 1 foot fall at this point. The right bank is low and liable to overflow. The left bank is high and not liable to overflow. The bed of the stream is rocky near the piers and muddy along the banks. The bridge has two spans. The central pier is protected by an ice and drift breaker, which extends about 125 feet upstream. No bench marks have been established.

The following measurements were made during 1902 by W. W. Schlecht and L. V. Branch:

July 21: Gage height, 5.06 feet; discharge, 5,537 second-feet.
September 9: Gage height, 3.67 feet; discharge, 1,891 second-feet.
November 6: Gage height, 4.18 feet; discharge, 3,131 second-feet.

Daily gage height, in feet, of Missouri River at Cascade, Mont.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						
1	.....	4.20	3.67	3.90	4.20	3.95
2	.....	4.15	3.55	3.95	4.20	4.00
3	.....	4.05	3.77	4.00	4.20	4.20
4	.....	3.90	3.87	4.05	4.20	4.50
5	.....	3.87	3.85	4.07	4.20	4.50
6	.....	3.75	3.75	4.05	4.18	4.50
7	.....	3.62	3.70	4.00	4.17	.....
8	.....	3.60	3.65	4.00	4.20	.....
9	.....	3.60	3.70	4.00	4.20	.....
10	.....	3.60	3.67	4.05	4.20	.....
11	.....	3.60	3.62	4.05	4.25	.....
12	.....	3.60	3.60	4.10	4.32	.....
13	.....	3.60	3.60	4.10	4.45	.....
14	.....	3.60	3.60	4.15	4.50	.....
15	.....	3.60	3.60	4.10	4.50	.....
16	.....	3.55	5.60	4.10	4.55	.....
17	5.35	3.50	3.65	4.10	4.55	.....
18	5.30	3.45	3.65	4.10	4.60	.....
19	5.22	3.55	3.70	4.10	4.57	.....
20	5.12	3.50	3.70	4.15	4.55	.....
21	5.00	3.72	3.70	4.15	4.50	.....
22	5.00	3.92	3.70	4.15	4.45	.....
23	4.90	3.90	3.70	4.10	4.20	.....
24	4.80	3.90	3.70	4.10	4.50	.....
25	4.70	3.87	3.70	4.10	4.00	.....
26	4.65	3.85	3.65	4.10	4.00	.....
27	4.60	3.85	3.62	4.10	4.00	.....
28	4.50	3.85	3.60	4.18	4.00	.....
29	4.40	3.82	3.65	4.20	4.00	.....
30	4.30	3.75	3.72	4.20	4.00	.....
31	4.30	3.70	.....	4.20	.....	.....

MISSOURI RIVER AT TOWNSEND, MONT.

The gaging station was established in 1891 by the Missouri River Commission, and readings have been made continuously since that time by an observer employed by the Commission. The locality is 2,504 miles above the mouth of the river. The following description of the gage, its location, and bench marks is from Lieut. J. C. Sanford, secretary of the Missouri River Commission:

A standard wire cable gage was erected by the Missouri River Commission October 1, 1891, on a county road bridge, located about 300 feet below the Northern Pacific Railroad bridge across the Missouri River near Townsend, Mont. Its zero is set at an approximate elevation of 3,700 feet above sea level as determined from a primary line of levels, run under the direction of the Commission in 1890, from Three Forks to Fort Benton, Mont., and starting from a bench mark of the Northern Pacific Railroad at Gallatin, Mont. (See Annual Report of Chief of Engineers, 1891.)

Reference bench mark is B. M. 10 (Townsend), described as "located on the right bank of the Missouri River, about one-half mile north of Townsend Railroad station, about one-half mile from river, measured in a perpendicular direction to track, and about three-fourths mile south of railroad bridge over the Missouri

River. It is about 60 feet west of a point on the track, 30 feet north of railroad bridge No. 392, and about 7 feet west of railroad fence. Compass reading to mile-post 1121 is 318°. Marked by stone and pipe; elevation, 3,795.991 feet. This elevation is erroneous, but is the elevation from which the gage is set.

The tabulated records of the Townsend gage are reductions to the St. Louis directrix datum obtained by subtracting 400.063 feet from the daily means of the gage readings. The gage reads from 3,785 to 3,799 feet.

Lieutenant Sanford states that since the establishment of the gage level lines have been completed connecting all of the upper river gages with the datum of the Missouri River Commission. Precise levels have been run up to Sioux City, Iowa, and above that checked Y lines have been run under the direction of Capt. H. F. Hodges, Corps of Engineers, United States Army, and of the Missouri River Commission. The elevations of the zeros of the other Montana gages read during 1890 are as follows:

Elevations of river gages in Montana.

Locality.	Above mouth.	Elevation of gage zero.	Locality.	Above mouth.	Elevation of gage zero.
	Miles.	*Feet.*		*Miles.*	*Feet.*
Great Falls	2,333.3	2,897.165	Toston	2,519.8	3,477.230
Craig	2,415.7	3,028.575	Gallahers Ferry	2,546.4	3,613.069
Stubbs Ferry	2,463.8	3,207.674	Gallatin Ferry	2,546.7	3,614.783

The area drained at this point is approximately 15,000 square miles, comprising, as above stated, the inflow from the Gallatin, the Madison, and the Jefferson rivers. This gage at Townsend is the highest of a series of twenty or more gages maintained permanently by the Missouri River Commission. Descriptions of these gages are given in the annual report of the Missouri River Commission, contained in the Annual Report of the Chief of Engineers, United States Army; that for 1891, on page 3819; for 1892, on page 3271, and for 1893, on page 2316. The distance of this point above Sioux City is 1,703 miles, and above Fort Benton, the next gage below maintained by the Corps of Engineers, 219 miles. In the report of the Chief of Engineers, United States Army, for 1893, page 2320, it is stated that there is under way an "examination of Missouri River from Three Forks to Canyon Ferry, Mont., with a view of determining at what points, if any, use might be made of water power for manufacturing and other purposes without unreasonably impairing the navigability. This part of the river was surveyed and mapped in 1890 under the direction of the Missouri River Commission. For the present work it is proposed to examine the maps of this survey and select such points as seem suitable to personally examine the localities, and by additional field work to get the necessary data for a report."

The gaging station on the upper Missouri River in the vicinity of Craig, referred to in previous reports, was abandoned in June, 1892, owing to the expense of maintenance and the fact that the Missouri River Commission had a gage at Townsend, Mont.

The results are furnished to the Geological Survey by the Corps of Engineers, United States Army.

Discharge measurements of Missouri River at Townsend, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 14	H. B. Waters	88.75	2,840
July 14	do	89.82	6,547
August 28	do	88.52	2,350

GALLATIN RIVER AT LOGAN, MONT.

This station was established on August 24, 1893, by F. H. Newell, at the railroad pump house immediately below the Northern Pacific main line bridge crossing Gallatin River at Logan, Mont. The gage was a vertical rod fastened to the cribwork box sunk in the river for the protection of the inlet pipe of the pump. The bench marks consist of nails driven into the angle of the pier of the bridge facing the gage, these being placed at the elevation of the 7, 8, 9, and 10 foot marks, and designated by corresponding figures. At the bridge itself measurements of volume can not well be made, as the stream is divided into four channels, being very swift in two of these, and obstructed by piles, snags, and sand in the others. Above the bridge, however, is a broad, straight course, where measurements can be made by means of a boat and cable.

On March 10, 1894, the gage rod was washed out, together with the crib to which it was attached, no discharge measurements having been made while it was in place.

On November 16, 1894, a new gage was established by Arthur P. Davis under the northeast corner of the Northern Pacific bridge above mentioned. This gage consisted of timbers partly inclined and partly vertical, the lower inclined portion being graduated from 0.60 foot up to 7.10 feet, and the vertical portion from 7 feet up to 12.10 feet. Bench mark No. 1 is on the head of a bridge spike, in the top of the pile stump to which the lower end of the inclined gage is fastened. Elevation 1.62 feet above zero of gage. Bench mark No. 2 is the head of a bridge spike driven horizontally into the first pier east of the river. It is driven into the north end, and is marked "B. M." Its elevation is 9.32 feet above the zero of the gage. The measurements were made by means of a cable across the river 100 yards above the bridge.

On September 16, 1896, a wire gage was placed in the east span of the railroad bridge and fastened to the guard rail on the upper side. The distance from the outside edge of the pulley to the end of the rod is 1 foot; from the end of the weight to the index marker 18.40 feet. Bench mark 1 is the top of the northeast corner of the iron plate at foot of diagonal end member of truss, east end, upper side,

and is 13.70 feet above datum. Bench mark 2 is a spike in pile stump, described and called "Bench mark No. 1," in the description of the 1894 gage. Discharge measurements are made from the cable across the river 300 feet above the railroad bridge. The section is a good one, the channel being straight for some distance above and below the cable. The bed is gravelly. The observer is James Martin. The following measurements were made in 1902:

Discharge measurements of Gallatin River at Logan, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 15	H. B. Waters	0.91	486
May 3	do	1.30	715
Do	do	1.30	720
May 28	do	4.23	4,018
July 14	do	1.66	986
August 29	do	.56	394

Daily gage height, in feet, of Gallatin River at Logan, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1		(a)	a1.05	1.30		4.40		0.80	0.60	1.10	1.10	1.40
2			1.05	1.30		4.30		.70	.60	1.10	1.10	1.20
3			1.05	1.30		3.75		.60	.60	1.10	1.10	1.20
4	(a)		1.05	1.30	1.30	3.55		.60	.60	1.10	1.10	1.30
5	1.00		1.05	1.30	1.20	3.25		.60	.60	1.10	1.10	1.40
6	1.00		1.05	1.30	1.20	3.35		.50	.60	1.10	1.20	1.30
7	1.00		1.05	1.30	1.30	3.35		.50	.60	1.10	1.10	1.30
8	1.00	(a)	1.04	1.30	1.40	4.15		.50	.60	1.10	1.20	1.30
9	1.00		1.40	1.30	1.60	4.10		.50	.60	1.10	1.20	1.20
10	1.00		1.40	1.30	1.60	4.30		.60	.60	1.10	1.20	1.20
11	a1.00		1.40	1.30	1.80	4.40		.60	.60	1.10	1.30	1.20
12	1.00		1.30	1.30	2.40	4.15		.60	.60	1.10	1.40	1.10
13	1.00		1.30		2.55	4.35		.60	.60	1.10	1.30	1.00
14	1.00		1.30		2.60	4.40	1.70	.60	.50	1.10	1.20	1.20
15	1.00	(a)	1.30		3.35	2.95	1.50	.70	.30	1.10	1.20	1.40
16	1.00	1.10	1.30		3.45	2.55	1.40	.70	.20	1.10	1.20	1.60
17	1.00	1.10	1.30		3.50	2.50	1.30	.70	.30	1.10	1.20	2.50
18	1.00	1.10	1.30		3.50	2.45	1.30	.80	.30	1.10	1.20	2.45
19		1.10	1.30		3.40	2.50	1.30	.80	.20	1.10	1.30	2.85
20		1.10	1.30		3.40	2.30	1.20	.70	.20	1.10	1.20	2.90
21		1.10	1.30		3.35	2.10	1.10	.70	.20	1.10	1.10	3.10
22		1.10	1.30		3.30	2.30	1.10	.70	.20	1.10	1.20	3.40
23	(a)	1.05	1.30		3.35	2.40	1.00	.70	.20	1.10	1.30	3.60
24		1.05	1.30		3.30	2.40	.90	.70	.20	1.10	1.40	3.35
25		1.05	1.30		3.10	2.30	.80	.60	.10	1.10	1.40	3.30
26		1.05	1.30		3.10	2.44	.80	.70	.10	1.10	1.40	3.30
27		1.05	1.30		3.45	2.10	.80	.60	.10	1.10	1.40	2.40
28		1.05	1.30		3.80	2.20	.90	.60	1.10	1.10	1.40	2.10
29			1.30		3.90		.80	.60	1.10	1.10	1.40	2.10
30			1.30		4.05		.80	.60	1.10	1.10	1.40	2.00
31			1.30		4.25		.70	.60		1.10		2.80

a Frozen at gage.

Rating table for Gallatin River at Logan, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	356	1.4	780	2.6	1,965	3.8	3,520
.4	370	1.6	940	2.8	2,200	4.0	3,830
.6	400	1.8	1,120	3.0	2,440	4.2	4,125
.8	450	2.0	1,315	3.2	2,700	4.4	4,430
1.0	530	2.2	1,520	3.4	2,960		
1.2	650	2.4	1,735	3.6	3,240		

Estimated monthly discharge of Gallatin River at Logan, Mont.

[Drainage area, 1,805 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January 5 to 18			530	14,717	0.29	0.15
February 16 to 28			576	14,856	.32	.15
March	780	560	678	41,693	.38	.44
April 1 to 12			710	16,899	.39	.18
May 4 to 31			2,328	129,291	1.29	1.34
June 1 to 28			2,775	154,136	1.54	1.60
July 14 to 31			599	21,398	.33	.22
August	450	382	410	25,206	.23	.27
September	590	356	399	23,742	.22	.25
October	590	590	590	36,278	.33	.38
November	780	590	679	40,383	.38	.42
December	3,240	530	1,465	90,079	.81	.93

WEST GALLATIN RIVER NEAR SALESVILLE, MONT.

The Salesville station, which has been maintained for a number of years, was established near Williams's ranch, about 16 miles southwest of Bozeman and near a highway bridge crossing the stream about 5 miles south of Salesville. A gage rod was erected in July, 1895, and observations were begun on August 1 by Ira T. Williams, a ranchman living about 600 feet away. The gage is spiked to a tree and is not liable to be washed out. The bench mark consists of a 6-inch spike driven in the top of a stump 5 feet north of the gage post. It is 6.71 feet above the zero of the gage, as lowered 5 feet

from the original position. A second bench mark consists of a 6-inch spike driven into the east bridge abutment. This is 9.26 feet above the zero of the gage. The initial point for soundings is on the right bank. In flood the water flows behind the bridge abutments on the right bank, but at other times is confined within the channel. The bed of the stream is composed of bowlders and is not liable to change. The velocity is great, rendering discharge measurements somewhat difficult. The channel is nearly straight, with slight curves both above and below. Two canals are taken out above this station, the West Gallatin Company carrying about 125 second-feet between July 1 and September 15, and the Kleinschmidt carrying about 50 second-feet between July 1 and August 15. In September, 1896, a wire gage was placed on the bridge, the pulley being fastened to the end of the rod opposite the 0.15-foot mark. The distance of the end of the weight to the index marker is 15.50 feet. The two gages were made to read the same.

The bench mark for the wire gage is the head of the southwest bolt in the rim of the southeast cylindrical pier. Its elevation is 13.70 feet above datum. The observer is Ira T. Williams, Salesville, Mont.

Discharge measurements of West Gallatin River near Salesville, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 28	H. B. Waters	2.83	373
June 3	A. P. Stover	5.30	2,629
Do	do	5.30	2,606
June 9	do	6.12	4,361
June 14	do	6.30	4,768
June 24	do	5.05	2,778
Do	do	5.05	2,779
July 10	do	4.25	1,074
July 17	H. B. Waters	4.14	1,348
August 13	A. P. Stover	3.30	627
September 4	H. B. Waters	2.80	433

Daily gage height, in feet, of West Gallatin River near Salesville, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.80	2.80	2.70	2.70	3.00	6.40	4.50	3.60	3.00	2.90	2.90	2.90
2	2.80	2.80	2.70	2.70	3.00	5.55	4.60	3.50	2.95	2.90	2.90	2.90
3	2.80	2.90	2.70	2.70	2.90	5.30	4.65	3.40	2.90	2.90	2.90	2.90
4	2.80	3.00	2.70	2.70	2.90	5.20	4.50	3.40	2.90	2.90	2.90	2.90
5	2.80	3.25	2.70	2.70	2.90	5.20	4.40	3.40	2.80	2.90	2.90	2.90
6	2.80	3.30	2.70	2.70	3.00	5.20	4.40	3.30	2.80	2.90	2.90	2.90
7	2.80	3.30	2.70	2.70	3.20	5.50	4.30	3.30	2.80	2.90	2.90	2.90
8	2.80	3.20	2.70	2.70	3.30	6.35	4.25	3.30	2.70	2.90	2.90	2.90
9	2.80	3.20	2.70	2.70	3.60	6.50	4.20	3.30	2.70	2.90	2.90	2.70
10	2.80	3.20	2.70	2.70	3.87	6.40	4.20	3.20	2.70	2.90	2.90	2.70
11	2.80	3.00	2.70	2.70	4.00	6.40	4.20	3.20	2.70	2.90	2.90	2.70
12	2.80	3.00	2.70	2.70	4.15	6.10	4.20	3.10	2.70	2.90	2.90	2.70
13	2.80	3.00	2.70	2.80	4.45	6.10	4.25	3.20	2.70	2.90	2.90	2.70
14	2.80	2.90	2.70	2.80	4.75	6.05	4.25	3.20	2.70	2.90	2.90	2.70
15	2.80	2.80	2.70	2.70	5.25	5.75	4.30	3.20	2.90	2.90	2.90	2.70
16	2.80	2.80	2.70	2.70	4.90	5.20	4.30	3.20	2.80	2.90	2.90	2.70
17	2.80	2.80	2.70	2.70	4.75	5.10	4.30	3.20	2.80	2.90	2.90	2.60
18	2.80	2.70	2.70	2.70	4.55	5.10	3.80	3.10	2.90	2.90	2.90	2.55
19	2.70	2.70	2.70	2.70	4.40	5.00	4.10	3.10	2.90	2.90	2.90	2.80
20	2.70	2.70	2.70	3.00	4.15	4.80	4.10	3.10	2.90	2.90	2.90	2.80
21	2.70	2.70	2.70	3.00	3.95	4.80	3.90	3.10	2.90	2.90	2.90	2.90
22	2.70	2.70	2.70	2.90	4.00	4.85	3.90	3.10	2.80	2.90	2.90	2.90
23	2.70	2.70	2.70	2.90	4.20	5.00	3.90	3.10	2.90	2.90	2.90	2.90
24	2.70	2.70	2.78	2.90	4.45	5.05	3.90	3.00	2.90	2.90	2.90	2.90
25	2.70	2.70	2.75	2.90	4.45	5.00	3.90	3.00	2.90	2.90	2.80	2.90
26	2.70	2.70	2.78	2.90	4.80	5.10	3.90	3.00	2.90	2.90	2.70	2.90
27	2.70	2.70	2.73	2.90	5.15	4.90	3.90	3.00	2.90	2.90	2.60	2.90
28	2.80	2.70	2.75	2.90	5.95	4.80	3.90	3.00	2.90	2.90	2.70	2.90
29	2.80	.....	2.75	2.90	6.25	4.50	3.70	3.00	2.90	2.90	2.90	2.90
30	2.80	.....	2.70	2.90	6.55	4.50	3.70	3.00	2.90	2.90	2.90	2.70
31	2.80	.....	2.70	.....	6.65	.....	3.70	3.00	.....	2.90	.....	2.70

Rating table for West Gallatin River near Salesville, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.6	300	3.8	930	5.0	2,285	6.2	4,550
2.8	400	4.0	1,060	5.2	2,605	6.4	5,000
3.0	500	4.2	1,215	5.4	2,950	6.6	5,450
3.2	600	4.4	1,415	5.6	3,310		
3.4	700	4.6	1,665	5.8	3,690		
3.6	810	4.8	1,960	6.0	4,100		

Estimated monthly discharge of West Gallatin River near Salesville, Mont.

[Drainage area, 860 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	400	360	388	23,881	0.45	0.52
February	650	360	449	24,962	.52	.54
March	400	360	365	22,413	.42	.48
April	500	360	399	23,742	.46	.51
May	5,565	450	1,697	104,370	1.97	2.27
June	5,225	1,530	3,025	180,030	3.52	3.93
July	1,735	870	1,192	73,269	1.39	1.60
August	810	500	591	36,327	.69	.80
September	500	360	422	25,081	.49	.55
October	450	450	450	27,669	.52	.60
November	450	300	437	26,023	.51	.57
December	450	270	407	25,031	.47	.54
The year	5,565	270	818	592,798	.95	12.91

MIDDLE CREEK NEAR BOZEMAN, MONT.

The station, established on August 3, 1895, is located 9 miles south of Bozeman and one-eighth of a mile above the old sawmill dam in the creek canyon. Discharge measurements are made from a wire cable placed across the stream in 1898. The gage is about 200 feet below the cable, and consists of a horizontal frame supporting a wire gage. Bench mark No. 1 consists of a spike driven horizontally into a stump 5 feet high about 80 feet east of the gage rod. The middle of this spike is at an elevation of 7.03 feet above gage datum. Bench mark No. 2 consists of an 8-inch bridge spike driven horizontally into a charred stump about 25 feet northeast of the gage, with an elevation of 3.58 feet. Bench mark No. 3 consists of a large rock 93 feet east of the gage, marked "B. M." in black paint, and is 4.84 feet above gage datum. The initial point for sounding is on the left bank. The water moves swiftly on one side; the left bank is low and liable to overflow. The bed of the stream is of gravel and is liable to change. Gage heights were not taken in 1897 and 1901, owing to the impossibility of securing an observer at moderate expense.

A new gage and three new bench marks were established at this station on May 8, 1902. Bench mark No. 1 is the top of a bowlder 56 feet southeast of the deadman of the east end of the cable. It is marked in red paint B. M., U. S. G. S., 8.41; elevation 8.41 feet above

the zero of the gage. Bench mark No. 2 is the top of a bowlder 68 feet southeast of the deadman, marked in red paint B. M., U. S. G. S., 9.26; elevation 9.26 feet above zero of the gage. Bench mark No. 3 is a large bowlder on the hillside 150 feet northeast of the deadman, marked B. M., U. S. G. S., 20.43; elevation 20.43 above the zero of the gage. The relation of the gage zeros has not been determined.

Discharge measurements of Middle Creek near Bozeman, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
May 7	J. S. Baker	1.02	55
Do	do	1.08	62
Do	do	1.12	67
June 4	A. P. Stover	1.45	156
Do	do	1.45	158
June 19	do	1.40	136
July 9	do	1.25	96
July 17	H. B. Waters	1.30	125
August 12	A. P. Stover	1.00	59
September 11	H. B. Waters	.81	41

Daily gage height, in feet, of Middle Creek near Bozeman, Mont.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Day.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							1902.						
1	.....	.....	1.50	1.10	0.90	0.85	17	1.50	1.60	1.35	1.00	0.80	.....
2	.....	1.60	1.50	1.10	.90	.85	18	1.40	1.50	1.30	1.00	.80	.....
3	.....	1.50	1.50	.....	.85	.85	19	1.30	1.50	1.25	.90	.80	.....
4	.....	1.40	1.45	1.10	.85	.....	20	1.30	1.45	.....	.90	.80	.....
5	.....	1.40	1.45	1.50	.85	.....	21	1.30	1.50	1.25	.90	.....	.....
6	.....	1.40	.....	1.50	.80	.....	22	1.30	.....	1.25	.90	.80	.....
7	.....	1.50	1.40	1.50	.....	.....	23	1.30	1.60	1.25	.90	.80	.....
8	.....	.....	1.35	1.50	.80	.....	24	1.40	1.60	1.25	.....	.80	.....
9	.....	1.60	1.35	1.00	.80	.....	25	1.40	1.65	1.25	.90	.85	.....
10	.....	1.80	1.35	.....	.80	.....	26	1.50	1.60	1.20	.90	.85	.....
11	.....	1.90	1.35	1.00	.80	.....	27	1.60	1.60	.....	.90	.85	.....
12	.....	1.80	1.35	1.00	.80	.....	28	1.70	1.50	1.15	.90	.....	.....
13	.....	1.70	.....	1.00	.80	.....	29	1.70	.....	1.10	.90	.85	.....
14	(a)	1.80	1.30	1.00	.....	.....	30	1.70	1.50	1.10	.90	.85	.....
15	1.60	.....	1.30	1.00	.80	.....	31	1.80	.....	1.10	.....	.....	.....
16	1.50	1.70	1.35	1.00	.80	.....							

[a] Observer did not read gage on Sundays.

Rating table for Middle Creek near Bozeman, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	49	1.1	72	1.4	136	1.7	271
.9	53	1.2	88	1.5	181	1.8	316
1.0	60	1.3	107	1.6	226	1.9	361

Estimated monthly discharge of Middle Creek near Bozeman, Mont.[a]

[Drainage area, 55 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1898.						
April 18 to 30			195	5,018	3.55	1.72
May	466	118	270	16,610	4.91	5.66
June	956	153	429	25,521	7.80	8.70
July	298	88	172	10,586	3.13	3.61
August	77	57	65	3,989	1.18	1.36
September	57	48	53	3,178	.96	1.07
October 1 to 21			52	2,255	.95	.78
1899.						
May 7 to 31			164	8,150	2.98	2.77
June	760	232	504	29,982	9.16	10.22
July	564	153	334	20,559	6.07	7.00
August	153	66	104	6,383	1.89	2.18
September	77	48	57	3,414	1.04	1.16
October	66	48	49	2,987	.89	1.03
1902.						
May 15 to 31			180	6,069	3.27	2.07
June	361	122	221	13,150	4.02	4.49
July	181	72	116	7,133	2.11	2.43
August	181	53	74	4,564	1.35	1.56
September	53	49	50	2,975	.91	1.02

[a] The results for 1898 and 1899, as previously published, were in error.

MADISON RIVER NEAR REDBLUFF, MONT.

This station is located at the ranch of the observer, Mrs. S. A. Black, 4 miles below the Redbluff iron county bridge over the Madison, and about 1½ miles below the mouth of Cherry Creek. It is also about 3 miles below the location of the old Redbluff station, described in Bulletin No. 131, on page 18. It was established May 2, 1897, at which time the one at Threeforks was discontinued. The vertical gage is fastened to a post set firmly into the bed of the river, and braced with cross-pieces from the bank. Discharge measurements are made from the iron bridge above. Cherry Creek is measured at the same time, as it enters between the gage and the bridge. The initial point for soundings is at the left abutment of the bridge. The banks are high and do not overflow. The bed of the stream is rocky and the current is quite swift. The following are the discharge measurements made during 1902 by H. B. Waters:

April 29: Gage height, 1.40 feet; discharge, 1,485 second-feet.
July 18: Gage height, 1.74 feet; discharge, 2,403 second-feet.
July 18: Gage height, 1.74 feet; discharge, 2,426 second-feet.
September 4: Gage height, 1.31 feet; discharge, 1,424 second-feet.

Daily gage height, in feet, of Madison River near Redbluff, Mont.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	(a)	1.00	1.40	3.00	1.95	1.40	1.30	1.30	1.30
2		1.00	1.40	3.00	2.00	1.40	1.30	1.30	1.30
3	(a)	1.20	1.40	2.75	2.00	1.40	1.30	1.30	1.30
4		1.20	1.40	2.51	2.10	1.35	1.30	1.30	1.30
5		1.20	1.40	2.50	2.00	1.30	1.30	1.30	1.30
6		1.30	1.43	2.45	2.00	1.30	1.30	1.30	1.30
7		1.30	1.45	2.35	1.95	1.30	1.30	1.30	1.30
8		1.30	1.50	2.35	1.90	1.30	1.30	1.30	1.30
9		1.30	1.50	2.55	1.80	1.30	1.30	1.30	(a)
10		1.30	1.50	2.85	1.80	1.30	1.30	1.30	
11	(a)	1.30	1.60	2.95	1.80	1.30	1.30	1.30	
12		1.30	1.70	2.95	1.80	1.30	1.30	1.30	
13		1.30	1.80	2.90	1.80	1.30	1.30	1.30	
14		1.30	1.90	2.90	1.80	1.30	1.30	1.30	
15		1.30	2.05	2.80	1.80	1.30	1.30	1.30	
16		1.30	2.20	2.60	1.80	1.30	1.30	1.30	
17	(a)	1.30	2.20	2.35	1.75	1.30	1.30	1.30	
18		1.35	2.20	2.25	1.70	1.30	1.30	1.30	
19		1.35	2.17	2.10	1.70	1.30	1.30	1.30	
20		1.40	2.10	2.20	1.70	1.30	1.30	1.30	
21		1.40	2.01	1.90	1.70	1.30	1.30	1.30	
22	(a)	1.40	1.90	1.90	1.60	1.30	1.30	1.30	
23	1.00	1.40	1.90	1.95	1.55	1.30	1.30	1.30	
24	1.00	1.40	1.90	2.00	1.50	1.20	1.30	1.30	
25	1.00	1.50	2.00	2.00	1.50	1.20	1.30	1.30	
26	1.00	1.50	2.15	2.10	1.50	1.20	1.30	1.30	
27	1.00	1.50	2.40	2.00	1.50	1.20	1.30	1.30	
28	1.00	1.50	2.60	1.90	1.50	1.20	1.30	1.30	
29	1.00	1.50	2.70	1.90	1.45	1.20	1.30	1.30	
30	1.00	1.40	2.85	1.90	1.40	1.20	1.30	1.30	
31	1.00		3.00		1.40	1.30		1.30	

a River frozen at gage January 1 to March 23, and November 9 to December 31.

Rating table for Madison River near Redbluff, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	910	1.6	2,075	2.2	3,745	2.8	5,540
1.1	1,025	1.7	2,325	2.3	4,035	2.9	5,840
1.2	1,175	1.8	2,600	2.4	4,345	3.0	6,140
1.3	1,360	1.9	2,880	2.5	4,655	3.1	6,440
1.4	1,570	2.0	3,160	2.6	4,935		
1.5	1,815	2.1	3,450	2.7	5,230		

Estimated monthly discharge of Madison River near Redbluff, Mont.

[Drainage area, 2,085 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March 23 to 31	.....	.....	910	16,245	0.44	0.15
April	2,075	910	1,436	85,448	.69	.77
May	6,140	1,570	3,001	184,524	1.44	1.66
June	6,440	2,880	4,336	258,010	2.08	2.32
July	3,450	1,570	2,435	149,722	1.17	1.35
August	1,570	1,175	1,361	83,685	.65	.75
September	1,360	1,360	1,360	80,926	.65	.73
October	1,360	1,360	1,360	83,623	.65	.75
November 1 to 8	.....	.....	1,360	21,580	.65	.19

JEFFERSON RIVER AT SAPPINGTON, MONT.

The station on this river is located at Sappington, 7 miles above Willow Creek, and was established by Arthur P. Davis November 13, 1894. The wire gage is fastened to the guard rail on the upper side of the Northern Pacific Railway bridge, 1 mile north of the railroad station. Bench mark No. 1 consists of a 6-inch wire nail driven horizontally in the east side of the blocking which forms the south abutment of the railroad bridge and is 6.90 feet above gage datum. Bench mark No. 2 is a 6-inch wire nail in a telegraph pole, about 30 feet south and east of the south abutment of the bridge, and is at an elevation of 7 feet on the gage. Bench mark No. 3 is the head of the northwest bolt fastening the switch standard to the cross-tie, 30 feet east of the bridge. Its elevation is 15.67 feet. On November 3, 1897, the rod was lowered eight-tenths of a foot, the subsequent years being adjusted to the new datum, but the balance of 1897 was corrected to agree with old datum. Discharge measurements are made

from a cable and car installed a short distance above the bridge. The following measurements were made during 1902 by H. B. Waters:

April 16: Gage height, 2.10 feet; discharge, 1,181 second-feet.
May 27: Gage height, 4.90 feet; discharge, 5,940 second-feet.
July 15: Gage height, 2.99 feet; discharge, 2,534 second-feet.
August 1: Gage height, 2.03 feet; discharge, 1,137 second-feet.
August 29: Gage height, 1.67 feet; discharge, 663 second-feet.

Daily gage height, in feet, of Jefferson River at Sappington, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	(a)	3.20		1.80	3.20	6.50	3.20	2.15	1.60	1.80	2.10	2.40
2				1.85	3.20	6.50	3.20	2.00	1.60	1.80	2.10	2.40
3				2.00	3.20	6.30	3.20	2.00	1.40	1.80	2.10	2.40
4				2.00	3.20	5.90	3.55	1.90	1.55	1.80	2.15	2.50
5	b 3.50			2.10	3.10	5.35	3.90	1.80	1.60	1.85	2.20	2.50
6				2.20	3.00	5.10	4.20	1.80	1.60	1.90	2.20	2.50
7				2.10	2.90	4.70	4.10	1.45	1.65	1.90	2.20	2.50
8		3.30		2.20	2.90	4.55	3.85	1.35	1.70	1.90	2.20	2.50
9				2.10	3.25	4.60	3.60	1.45	1.70	1.90	2.20	2.50
10				2.20	3.55	4.60	3.55	1.60	1.70	1.90	2.20	2.50
11	b 3.20			2.25	3.85	4.70	3.30	1.50	1.65	1.90	2.25	2.50
12				2.10	4.05	5.10	3.20	1.50	1.60	1.90	2.30	2.50
13				2.00	4.10	5.10	3.15	1.65	1.60	2.00	2.30	2.50
14				2.20	4.30	5.10	3.00	1.70	1.60	2.00	2.35	2.50
15		3.40		1.95	4.65	5.10	2.95	1.70	1.60	2.00	2.40	2.50
16				2.00	5.20	4.95	2.75	1.70	1.60	2.00	2.40	2.40
17				2.10	5.50	4.70	2.70	1.70	1.60	2.00	2.40	2.30
18				2.10	5.40	4.10	2.65	1.80	1.65	2.00	2.40	2.30
19				2.20	5.10	3.80	2.65	1.80	1.70	2.00	2.50	2.30
20				2.40	5.00	3.55	2.80	1.90	1.70	2.00	2.50	2.30
21				3.20	5.00	3.45	2.70	1.85	1.70	2.00	2.45	2.30
22		3.40		3.55	4.80	3.30	2.65	1.80	1.70	2.00	2.40	2.30
23				3.60	4.60	3.20	2.50	1.70	1.70	2.00	2.30	2.30
24				3.60	4.75	3.20	2.50	1.70	1.70	2.00	2.30	2.30
25	3.40			3.60	4.80	3.20	2.40	1.70	1.70	2.10	2.30	2.40
26				3.35	4.80	3.15	2.35	1.70	1.70	2.10	2.30	2.40
27				3.30	4.85	3.10	2.20	1.70	1.75	2.10	2.30	2.40
28				3.30	5.15	3.10	2.20	1.70	1.80	2.10	2.30	2.40
29				3.30	5.60	3.10	2.20	1.70	1.80	2.10	2.30	2.40
30			2.00	3.20	6.25	3.20	2.10	1.60	1.80	2.10	2.30	2.40
31			1.90		6.60		2.10	1.60		2.10		2.40

a Weekly observations during January, February, and March. b Ice at gage.

Rating table for Jefferson River at Sappington, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	510	2.8	2,230	4.2	4,640	5.6	7,305
1.6	685	3.0	2,550	4.4	5,000	5.8	7,695
1.8	875	3.2	2,870	4.6	5,365	6.0	8,085
2.0	1,090	3.4	3,205	4.8	5,750	6.2	8,475
2.2	1,335	3.6	3,550	5.0	6,140	6.4	8,865
2.4	1,610	3.8	3,905	5.2	6,525	6.6	9,255
2.6	1,915	4.0	4,270	5.4	6,915		

Estimated monthly discharge of Jefferson River at Sappington, Mont.

[Drainage area, 8,984 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	3,550	875	1,875	111,570	0.21	0.23
May	9,255	2,390	5,028	309,160	.56	.65
June	9,060	2,710	5,081	302,340	.57	.64
July	4,640	1,210	2,502	153,842	.28	.32
August	1,150	485	801	49,252	.09	.10
September	875	645	739	43,974	.08	.09
October	1,210	875	1,059	65,115	.12	.14
November	1,755	1,210	1,460	86,876	.16	.18
December	1,755	1,470	1,630	100,225	.18	.21

Miscellaneous measurements in Missouri River drainage basin.

[Made by B. E. Forbes, J. C. Stevens, Adna Dobson, A. B. Crane, and H. B. Waters.]

NEBRASKA.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
August 9	Long Pine Creek	Long Pine	49.7
March 22	Minnechaduza Creek	Valentine	38.1
April 11	do	Sec. 29, T. 35, R. 30 W	14.9
Do	do	Sec. 2, T. 34, R. 30 W	17.3
Do	do	Sec. 8, T. 34, R. 29 W	26.0
Do	do	Sec. 30, T. 34, R. 38 W	33.8
April 12	do	Valentine	38.3
June 5	do	do	23.1
July 4	do	do	27.4
July 20	do	do	22.7
August 20	do	do	23.8
March 22	Niobrara River	Fort Niobrara	1,226
April 12	do	do	877
June 3	do	W. line sec. 26, T. 29, R. 46 W.	25.4
June 15	do	Fort Niobrara	588
July 4	do	do	714
July 20	do	do	705
June 2	White River	Sec. 34, T. 32, R. 52 W	64.9
August 20	do	Sec. 25, T. 32, R. 52 W	10.4
November 8	Big Sioux	Sioux Falls, S. Dak	46.4

Miscellaneous measurements in Missouri River drainage basin—Continued.

MONTANA.

Date.	Stream.	Locality.	Gage height.	Discharge.
1902.			*Feet.*	*Second-feet.*
August 28	Crow Creek	Radersburg	1.85	18.14
Do	do	do	1.85	18.89

PLATTE RIVER DRAINAGE BASIN.

The Platte River, one of the largest tributaries of the Missouri, is formed by the junction of the North and South Platte rivers in Lincoln County, Nebr., and flows east into the Missouri River 18 miles south of Omaha, Nebr. The principal tributaries of the Platte in Nebraska are the Elkhorn and the Loup rivers. The Elkhorn River rises in the northern part of Nebraska and flows southeast into the Platte about 35 miles above its mouth. The North, Middle, and South Loup rivers, with their tributaries, drain north central Nebraska and join the Platte River near Columbus, Nebr.

The North Platte River rises in northern Colorado, flows north into Wyoming and then east into Nebraska. The Sweetwater and the Laramie rivers are its principal tributaries. The Sweetwater joins it from the west in south central Wyoming. The Laramie River rises in the northern part of Colorado and flows north into the North Platte in eastern Wyoming. The Little Laramie is a small tributary of the Laramie River in southern Wyoming.

The South Platte River rises in central Colorado, flows north, then east to its junction with the North Platte River. Its tributaries are mostly small creeks. Big Thompson Creek joins it 8 miles south of Greeley, Colo. St. Vrain Creek joins it about 15 miles south of Greeley. Clear Creek joins it about 3 miles north of Denver, and Bear Creek 8 miles south of Denver.

The following list includes the stations in the Platte River drainage basin:

Elkhorn River near Arlington, Nebr.
Elkhorn River near Norfolk, Nebr.
Loup River at Columbus, Nebr.
Platte River near Columbus, Nebr.
Platte River near Lexington, Nebr.
North Platte River at North Platte, Nebr.
North Platte River at Bridgeport, Nebr.
North Platte River at Mitchell, Nebr.
North Platte River at Guernsey, Wyo.
Little Laramie River at Mays Ranch, near Hatton, Wyo.
Sweetwater River near Splitrock, Wyo.

South Platte River at Bigspring, Nebr.
South Platte River at Julesburg, Colo.
Middle Crow Creek near Hecla, Wyo.
South Platte River at Kersey, Colo.
Big Thompson Creek near Arkins, Colo.
St. Vrain Creek at Lyons, Colo.
Clear Creek at Forkscreek, Colo.
South Platte River at Denver, Colo.
Bear Creek near Morrison, Colo.
South Platte River at South Platte, Colo.

ELKHORN RIVER NEAR ARLINGTON, NEBR.

The station at Arlington, Nebr., was established by Glenn E. Smith April 28, 1899, and is located at the wagon bridge 1 mile west of the town of Arlington. The original rod was fastened to cross-ties, which are solidly bedded in the river bank. It consisted of a new oak stake 3 by 4 inches and 12 feet long. It was placed 200 feet downstream from the bridge on the west bank of the river. Bench mark No. 1 is a large spike driven in a pile 50 feet upstream from the rod, and is 6.36 feet above gage datum. Bench mark No. 2 is a large spike driven in a piling 20 feet back and 10 feet upstream from the rod, and is 9.12 feet above gage datum. Bench mark No. 3 is a vertical spike driven into a small leaning tree 5 feet downstream from the rod, and is 7.43 feet above gage datum. On May 10, 1899, the rod was washed out; on May 29 it was replaced by an oak rod 2 by 6 inches and 16 feet long. This rod was placed on the same bank as the first rod, but was set 25 feet farther upstream. The gage datum was not changed. Mike Hammang, a farmer living about 300 yards from the gage rod, is the observer.

Discharge measurements of Elkhorn River near Arlington, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
March 19	J. C. Stevens and B. E. Forbes	1.85	771
April 14	J. C. Stevens	2.15	920
Do	do	2.15	928
June 17	do	1.85	743
July 7	do	6.29	4,363
July 29	do	3.57	1,402
August 22	do	3.75	1,388
September 10	do	2.10	805
Do	do	2.10	796
October 4	J. C. Stevens and Ferd Bonstedt	4.79	2,676
Do	do	4.78	2,661

Daily gage height, in feet, of Elkhorn River near Arlington, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.										
1	.....	2.24	3.20	1.90	1.80	4.95	3.47	4.20	2.88	2.01
2	.....	2.39	3.23	1.88	1.99	4.15	3.12	5.15	2.86	2.10
3	.....	2.51	3.30	1.82	2.20	3.37	2.80	5.07	2.76	[illegible]
4	.....	2.73	3.12	1.72	2.85	3.00	2.64	4.80	2.75	.....
5	.....	2.89	2.71	1.82	3.57	2.75	2.52	4.73	2.72	.....
6	.....	2.83	2.44	1.88	5.80	2.56	2.40	4.60	2.67	.....
7	.....	2.75	2.31	1.75	6.17	2.35	2.24	4.39	2.63	.....
8	.....	2.67	2.23	1.74	5.90	2.21	2.20	4.26	2.58	.....
9	(a)	2.62	2.15	1.99	8.16	2.14	2.17	4.17	2.60	.....
10	3.74	2.50	2.14	2.85	9.10	2.00	2.00	4.06	2.58	.....
11	3.34	2.39	2.08	2.76	8.78	1.95	1.97	4.01	2.56	.....
12	3.17	2.32	2.00	2.60	7.65	1.82	1.94	4.54	2.62	.....
13	3.19	2.21	2.01	2.31	7.66	1.88	1.90	5.14	2.87	.....
14	3.36	2.12	2.02	2.14	7.41	1.81	1.80	5.10	3.30	.....
15	3.37	2.13	1.98	2.10	6.10	2.25	1.76	4.71	3.16	.....
16	3.02	2.12	1.88	1.93	5.85	4.97	1.72	4.28	2.88	.....
17	3.83	2.07	1.87	1.82	5.52	5.50	1.68	4.02	2.76	.....
18	(a)	1.98	1.82	1.91	6.11	4.29	1.61	3.86	2.64	.....
19	(a)	1.96	1.77	2.27	7.11	3.59	1.55	3.72	2.58	.....
20	2.25	1.91	1.75	2.44	7.15	3.08	1.54	3.65	2.55	.....
21	2.32	1.84	1.80	2.15	6.92	2.70	2.06	3.49	2.47	.....
22	2.71	1.80	1.85	1.92	6.50	3.80	2.60	3.42	2.50	.....
23	2.57	1.77	1.93	1.81	5.69	3.44	3.25	3.39	2.47	.....
24	2.42	1.79	1.98	1.75	4.71	3.90	3.59	3.29	2.46	.....
25	2.35	1.75	2.00	1.72	4.06	4.18	3.58	3.22	2.36	.....
26	2.36	1.82	1.95	1.61	4.30	4.57	3.40	3.16	2.32	.....
27	2.28	1.92	1.89	1.60	4.22	5.18	3.45	3.06	2.28	.....
28	2.22	1.95	1.92	1.58	3.86	5.23	3.57	2.96	2.26	.....
29	2.23	2.11	1.90	1.70	3.51	5.06	3.46	2.95	2.24	.....
30	2.21	2.65	1.94	1.74	3.12	5.57	3.92	2.91	2.14	.....
31	2.18	.....	1.90	.....	3.66	3.90	.....	2.82	.....	.....

[a] Operations discontinued from January 1 to March 10, and from December 3 to 31, on account of ice.

Rating table for Elkhorn River near Arlington, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	238	2.0	740	3.6	1,706	5.2	3,398
.6	276	2.2	833	3.8	1,882	5.4	3,656
.8	322	2.4	932	4.0	2,067	5.6	3,925
1.0	375	2.6	1,037	4.2	2,263	5.8	4,203
1.2	435	2.8	1,149	4.4	2,469	6.0	4,494
1.4	501	3.0	1,268	4.6	2,686	6.2	4,797
1.6	574	3.2	1,393	4.8	2,913		
1.8	654	3.4	1,542	5.0	3,150		

[a] This table was applied indirectly according to the method outlined on p. 323 of Nineteenth Ann. Rept., U. S. Geol. Surv., pt. 4.

Estimated monthly discharge of the Elkhorn River near Arlington, Nebr.

[Drainage area, 5,980 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March, 18 days			1,251	44,664	0.21	0.14
April	1,342	731	974	57,950	.16	.18
May	1,640	718	931	57,240	.16	.18
June	1,220	465	781	46,465	.13	.14
July	9,568	585	3,633	223,350	.61	.69
August	3,114	471	1,453	89,341	.29	.33
September	1,846	530	1,001	59,560	.17	.19
October	3,199	1,161	2,034	125,050	.34	.39
November	1,463	804	1,051	62,530	.18	.19

ELKHORN RIVER NEAR NORFOLK, NEBR.

The gaging station established July 16, 1896, is located about 2 miles south of Norfolk, Nebr., near the line of Thirteenth street extended. The gage is on the left bank of the river. It consists of an inclined oak piece, 2 by 4 inches, 12 feet long, resting on beveled blocks which rest in turn on horizontally bedded cross-ties. All are firmly fastened together by lag screws. The zero of the gage is 8.21 feet below a small spike driven horizontally into a tree near the root, about 20 feet back, and downstream from the gage. Also, the zero of the gage is 3.96 feet below the head of a lag screw which is placed vertically in the horizontal trunk of a large living willow tree which overhangs the stream about 15 feet below the gage. Bench mark 3 is a standard 4-foot iron pipe of the United States Geological Survey, located 35 feet west and 7 feet north of the top of the gage, and 15.5 feet west of the ash tree on which is bench mark 1. Its elevation is 10.70 feet above the zero of the gage. The observer is Harold Taft, a farmer boy, whose home is about 300 yards from the gage. The river bed at the station is composed of sand and mud.

Discharge measurements of Elkhorn River near Norfolk, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902		*Feet.*	*Second-feet.*
March 21	J. C. Stevens	2.39	570
April 13	do	2.22	534
May 12	do	2.16	483
June 16	do	2.54	551
July 3	do	4.36	1,376
July 26	do	2.45	475
August 22	do	1.78	296
September 29	do	5.65	2,497
November 14	do	2.34	502

Daily gage height, in feet, of Elkhorn River near Norfolk, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1		2.95	2.55	2.50	1.90	1.90	2.35	5.92	2.88
2		3.25	2.60	2.35	3.11	1.90	2.70	5.76	2.71
3		3.45	2.60	2.20	4.48	1.85	2.50	5.52	2.69
4		3.20	2.55	2.10	4.00	1.85	2.40	5.35	2.65
5		3.20	2.55	2.95	3.55	1.83	2.10	4.73	2.65
6		2.97	2.50	3.07	3.05	1.81	1.90	4.60	2.59
7		2.90	2.50	2.50	2.90	1.80	1.95	4.39	2.58
8		2.85	2.45	2.55	2.72	1.79	1.97	4.26	2.58
9	(a)	2.80	2.40	2.50	2.80	1.77	1.95	4.17	2.47
10	2.55	2.70	2.30	2.40	2.85	1.75	1.99	4.06	2.47
11	2.60	2.50	2.25	2.35	2.85	1.75	2.00	4.01	2.43
12	2.62	2.32	2.20	2.20	2.90	1.73	2.01	4.26	2.30
13	2.75	2.20	2.20	2.10	2.90	1.70	2.00	4.10	2.21
14	2.72	2.15	2.15	2.40	3.40	1.68	1.98	3.88	2.10
15	2.72	2.15	2.10	2.40	4.00	1.65	1.93	3.66	2.15
16	(a)	2.12	2.15	2.70	3.85	1.70	1.90	3.41	2.03
17	(a)	2.13	2.20	2.80	3.55	1.70	1.85	3.01	1.99
18	(a)	2.15	2.30	2.75	3.85	1.73	1.85	2.97	1.97
19	(a)	2.13	2.60	2.70	3.00	1.75	1.84	3.72	1.97
20	2.65	2.10	2.80	2.61	3.40	1.75	2.00	3.65	2.03
21	2.52	2.15	2.85	2.50	3.25	1.78	2.35	3.49	2.03
22	2.45	2.10	2.80	2.30	3.05	1.80	2.45	3.42	2.09
23	2.42	2.10	2.75	2.22	2.90	1.85	2.37	3.39	2.13
24	2.38	2.01	2.75	2.12	2.85	2.00	2.65	3.29	a 1.12
25	2.40	2.00	2.70	1.95	2.60	2.63	2.83	3.22	a 1.22
26	2.40	2.20	2.60	1.85	2.49	2.78	3.10	3.16	a 1.26
27	2.40	2.35	2.61	1.82	2.40	2.90	3.47	3.06	.....
28	2.45	2.35	2.61	1.80	2.00	3.00	4.89	2.96	.....
29	2.38	2.45	2.60	1.75	2.19	2.60	5.69	2.95	.....
30	2.35	2.50	2.55	1.75	2.10	2.10	5.94	2.91	.....
31	2.30	.....	2.55	.....	2.00	2.10	.....	2.82	.....

a Observations discontinued from Jan. 1 to Mar. 9 and from Nov. 27 to Dec. 31 on account of ice.

Rating table for Elkhorn River near Norfolk, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	140	2.4	493	4.0	1,324	5.6	2,480
1.0	162	2.6	575	4.2	1,444	5.8	2,660
1.2	192	2.8	668	4.4	1,570	6.0	2,840
1.4	227	3.0	763	4.6	1,704	6.2	3,020
1.6	270	3.2	860	4.8	1,843	6.4	3,200
1.8	319	3.4	971	5.0	1,987	6.6	3,380
2.0	370	3.6	1,087	5.2	2,135	6.8	3,560
2.2	425	3.8	1,205	5.4	2,300		

[a] This table was applied indirectly according to the method outlined on page 323 of Nineteenth Ann. Rept. U. S. Geol. Surv., pt. 4.

Estimated monthly discharge of the Elkhorn River near Norfolk, Nebr.

[Drainage area, 2,474 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March, 18 days			591	21,100	0.24	0.16
April	1,028	444	651	38,730	.26	.29
May	773	471	616	37,870	.25	.29
June	840	259	490	29,154	.20	.22
July	1,462	287	710	43,650	.29	.33
August	729	263	354	21,764	.14	.16
September	2,750	319	642	38,200	.26	.29
October	2,597	668	1,265	77,770	.51	.59
November 1 to 23			482	21,990	.19	.16

LOUP RIVER AT COLUMBUS, NEBR.

Observations at this station were begun October 13, 1894.

This station is located near the iron bridge of the Union Pacific Railway, just west of Columbus, Nebr. The observer is David J. Mowery, who lives in Columbus. The gage is 50 yards from the bridge, and is of oak, 3 by 6 inches, 12 feet long, fastened by lag screws to a pile, which forms part of the training works above the bridge. The rod is vertical. The 12-foot mark on the rod is 7 feet below a point 2 feet east of the third panel point of the north truss of the east span, counting the end of the span as the first panel point. Bench mark 2 is the regulation 4-foot iron post of the United States Geological Survey, placed 72 feet east of gage rod. Its elevation is 13.27 feet above zero of gage. Gagings are made from a cable which spans the stream about 50 yards above the bridge.

Discharge measurements of Loup River at Columbus, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 8	Frank Dobson	5.79	6,826
April 13	do	4.76	2,532
May 11	do	4.81	2,203
May 22	J. C. Stevens	5.56	4,039
June 1	do	4.85	2,588
July 11	do	5.59	6,586
August 10	do	6.10	7,685
August 26	do	5.55	6,901
September 11	do	4.48	2,514
October 5	J. C. Stevens and Ferd Bonstedt	5.05	3,156

Daily gage height, in feet, of Loup River at Columbus, Nebr.[a]

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	.....	4.65	4.80	4.85	6.00	4.80	5.40	5.00	4.79
2	.....	4.60	4.80	4.95	6.60	4.70	5.10	5.00	4.80
3	.....	4.55	4.80	5.00	6.80	4.60	4.60	5.00	4.80
4	.....	4.50	4.85	5.40	6.10	4.60	4.55	5.00	4.85
5	.....	4.60	4.90	5.80	6.10	4.55	4.50	4.92	4.85
6	.....	4.80	5.00	5.90	6.05	4.50	4.50	4.95	4.85
7	.....	4.70	5.10	5.95	6.10	4.45	4.50	4.95	4.90
8	5.79	4.70	5.00	5.00	6.00	4.40	4.45	4.90	4.95
9	5.79	4.70	4.95	4.90	5.90	5.00	4.45	4.80	4.95
10	5.00	4.70	4.90	4.85	6.45	6.10	4.45	4.80	4.95
11	4.70	4.70	4.80	4.70	5.59	4.90	4.48	5.00	4.80
12	4.60	4.73	4.80	4.65	5.25	4.70	4.45	5.60	4.70
13	4.70	4.76	4.90	4.65	5.00	4.65	4.40	5.50	4.65
14	4.80	4.75	5.10	4.60	5.50	4.62	4.40	5.40	4.65
15	4.80	4.75	5.30	4.60	5.25	4.60	4.35	5.30	4.65
16	4.80	4.70	5.80	4.70	5.10	4.60	4.30	5.20	4.60
17	4.70	4.70	5.30	4.65	5.05	4.60	4.20	5.10	4.65
18	4.70	4.70	5.70	4.65	5.10	5.00	4.40	5.00	4.70
19	4.60	4.70	5.90	5.00	5.10	5.55	4.50	4.90	4.75
20	4.60	4.70	6.10	5.40	5.00	5.50	4.65	4.90	4.80
21	4.64	4.70	5.56	5.00	4.90	5.50	4.80	4.90	4.80
22	4.65	4.75	5.55	4.95	4.80	5.40	5.80	4.90	4.80
23	4.68	4.80	5.50	4.70	4.75	5.40	6.10	4.90	4.81
24	4.70	4.80	5.40	4.80	4.70	5.30	5.10	4.90	4.85
25	4.80	4.80	5.36	4.70	4.80	5.50	5.10	4.90	4.85
26	4.90	4.85	5.15	4.60	4.85	5.55	5.10	4.90	4.85
27	4.95	5.15	5.00	4.80	4.80	5.45	5.40	4.90	4.85
28	4.97	5.10	4.95	4.80	4.85	5.50	5.20	4.85	4.85
29	5.00	5.00	4.90	5.00	4.85	5.59	5.10	4.85	4.85
30	4.80	4.90	4.85	5.00	4.85	5.80	5.05	4.80	.....
31	4.70	.....	4.85	.....	4.80	5.95	.....	4.80	.....

[a] Observations discontinued from January 1 to March 8, and from November 29 to December 31, on account of ice.

Rating table for Loup River at Columbus, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.8	1,140	4.6	2,040	5.4	4,101	6.2	6,760
3.9	1,175	4.7	2,265	5.5	4,402	6.3	7,134
4.0	1,225	4.8	2,500	5.6	4,712	6.4	7,517
4.1	1,300	4.9	2,743	5.7	5,031	6.6	8,311
4.2	1,400	5.0	2,995	5.8	5,358	6.8	9,149
4.3	1,510	5.1	3,258	5.9	5,694	7.0	10,025
4.4	1,660	5.2	3,530	6.0	6,040	7.2	10,941
4.5	1,825	5.3	3,811	6.1	6,396		

[a] This table was applied indirectly according to the method outlined on page 323, 19th Ann. Rept., U. S. Geol. Surv., pt. iv.

Estimated monthly discharge of the Loup River at Columbus, Nebr.

[Drainage area, 13,542 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March, 24 days			3,343	159,156	0.25	0.22
April	3,206	1,976	2,409	143,385	.18	.20
May	7,443	2,203	3,226	198,334	.24	.28
June	5,936	2,211	3,250	193,375	.24	.27
July	10,895	3,394	5,669	348,530	.42	.48
August	8,152	2,463	4,767	293,115	.35	.40
September	6,909	1,693	3,218	191,487	.24	.27
October	4,712	2,500	3,011	185,116	.22	.25
November, 29 days	2,869	2,040	2,501	143,859	.19	.20

PLATTE RIVER NEAR COLUMBUS, NEBR.

This station was established in 1895, and is located on the left bank of the main channel of the river, 75 feet above the Meridian bridge south of Columbus. It is about 4 miles above the mouth of the Loup River. The gage consists of an inclined oak timber fastened to cross-ties which are embedded in the bank of the river. The channel is straight both above and below the gage. The bench mark is a standard 4-foot iron post of the United States Geological Survey, and is located 44.5 feet east of the gage, 60 feet north of the north end of the north bridge truss, and 10 feet west of a cottonwood tree 6 inches in diameter. Its elevation is 7.06 feet above gage datum.

The initial point for soundings is the north end of the upstream side of the bridge.

David J. Mowery, who lives in Columbus, is the observer.

Discharge measurements of Platte River near Columbus, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 8	Frank Dobson	3.39	5,664
April 13	do	2.22	996
May 11	do	2.37	1,695
May 22	J. C. Stevens	3.85	8,447
June 1	do	3.39	5,852
July 11	do	3.55	6,992
August 10	do	1.31	350
August 26	do	1.60	546
September 11	do	.50	5
October 5	J. C. Stevens and Ferd Bonstedt	2.50	1,989

Daily gage height, in feet, of Platte River near Columbus, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	.....	2.80	2.30	3.38	3.40	1.90	1.10	1.95	1.80
2	.....	2.60	2.25	3.39	3.60	1.80	1.10	2.00	1.90
3	.....	2.40	2.20	3.39	3.60	1.70	1.10	2.20	1.95
4	.....	2.30	2.40	3.40	4.00	1.50	1.00	2.40	2.00
5	.....	2.35	2.50	3.55	4.10	1.35	1.00	2.50	2.00
6	.....	2.10	2.65	3.90	4.10	1.20	1.00	2.75	2.00
7	(a)	2.15	2.75	3.80	4.00	1.10	1.10	2.75	2.00
8	3.39	2.15	2.85	3.85	4.00	1.05	1.00	2.50	1.95
9	3.38	2.20	2.85	3.70	3.90	1.00	.90	2.30	1.90
10	3.30	2.20	2.86	3.65	3.75	1.30	.80	2.30	1.90
11	3.00	2.20	2.87	3.50	3.50	1.10	.50	2.40	1.80
12	2.90	2.21	2.90	3.40	3.40	1.00	.45	2.80	1.70
13	2.80	2.22	2.90	3.20	3.20	.90	.40	3.00	1.70
14	2.80	2.20	3.00	3.20	3.21	1.10	.40	3.20	1.80
15	2.80	2.20	3.20	3.05	3.00	1.20	.30	3.30	2.00
16	2.80	2.15	3.35	3.25	2.89	1.10	.20	3.00	2.00
17	2.70	2.15	3.45	3.40	2.80	1.00	.20	2.95	2.10
18	2.40	2.10	4.00	3.55	2.80	1.00	.20	2.90	2.10
19	2.30	2.10	4.30	3.55	3.05	1.00	.40	2.60	2.05
20	2.20	2.15	4.20	3.50	3.38	1.00	.65	2.50	2.05
21	2.20	2.10	3.85	3.50	3.00	1.40	.70	2.40	2.10
22	2.10	2.05	3.84	3.50	2.90	2.20	1.00	2.30	2.10
23	2.10	1.95	3.82	3.40	2.80	2.00	1.85	2.20	2.10
24	2.50	1.97	3.80	3.40	2.70	1.90	1.85	2.10	2.10
25	2.70	2.00	3.75	3.40	2.60	1.60	1.85	2.05	2.05
26	3.00	2.10	3.70	3.40	2.50	1.20	1.90	2.05	2.05
27	3.10	2.09	3.60	3.40	2.40	1.30	1.95	2.00	2.00
28	3.10	2.10	3.50	3.42	2.30	1.30	1.95	1.95	1.95
29	3.10	2.15	3.39	3.40	2.20	1.30	1.90	1.85	1.95
30	3.00	2.25	3.38	3.40	2.10	1.30	1.85	1.85	(a)
31	2.90	.....	3.38	.....	2.05	1.20	.....	1.85	.....

a Observations discontinued from January 1 to March 8 and from November 29 to December 31 on account of ice.

Rating table for Platte River near Columbus, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	190	2.0	825	3.0	3,100	4.0	9,150
1.1	220	2.1	925	3.1	3,500	4.2	11,250
1.2	250	2.2	1,025	3.2	4,000	4.4	13,550
1.3	285	3.3	1,150	3.3	4,500	4.6	16,400
1.4	340	2.4	1,275	3.4	5,000	4.8	19,700
1.5	400	2.5	1,400	3.5	5,500	5.0	23,700
1.6	475	2.6	1,676	3.6	6,050	5.2	28,400
1.7	550	2.7	1,984	3.7	6,700	5.4	33,700
1.8	635	2.8	2,324	3.8	7,400		
1.9	725	2.9	2.696	3.9	8,200		

[a] This table was applied indirectly according to the method outlined on page 323, 19th Ann. Rept. U. S. Geol. Surv., Pt. IV.

Estimated monthly discharge of the Platte River near Columbus, Nebr.

[Drainage area 56,867 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March 9 to 31			2,817	134,098	0.050	0.045
April	2,398	825	1,076	64,022	.019	.021
May	13,800	1,212	5,462	335,845	.096	.111
June	9,950	4,150	6,426	382,347	.113	.126
July	11,140	995	5,267	323,805	.093	.107
August	1,150	190	404	24,837	.007	.008
September	975	0	337	20,051	.006	.007
October	5,000	690	1,798	110,554	.032	.037
November	925	635	796	47,365	.014	.016

PLATTE RIVER NEAR LEXINGTON, NEBR.

This station was established April 2, 1902, by H. O. Smith. It is located on the highway bridge, 2½ miles south of Lexington, Nebr. The gage is of the usual wire type, the scaleboard being graduated to feet and half-tenths. It is protected by a box and securely fastened to the upstream hand rail of the bridge, about 100 feet from the north end. It is read daily by Charles Freeman, a farmer living near by. The channel is straight both above and below the station.

The banks are low, but do not overflow. The bed of the stream is sandy and shifting. Bench mark No. 1 is a hub on the west side of the bridge approach. Its elevation is 2,391.90 feet above sea level. Bench mark No. 2 is the top of the east end of the first cap at the north end of bridge. Its elevation is 2,393.31 feet above sea level. The elevation of the water surface, or the end of the weight, when the gage reads zero, is 2,385.65 feet.

Discharge measurements of Platte River near Lexington, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 8	H. O. Smith and B. E. Forbes		2,293
May 2	H. O. Smith	2.85	2,693
May 22	do	3.38	7,764
June 3	do	3.00	3,038
June 18	do	3.25	6,555
July 5	do	2.98	4,993
July 19	do	2.30	1,002
July 29	do	2.25	185
August 2	do	2.00	0
August 23	do	1.20	0
September 25	do	2.85	2,829
November 8	do	2.70	1,127

Daily gage height, in feet, of Platte River near Lexington, Nebr.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1		2.95	3.25		2.35	1.70	2.45	2.70	2.80
2		2.85	2.95		2.00	1.60	2.55	2.60	2.70
3		2.80	2.90		1.95	1.50	2.55	2.65	2.30
4		2.75	3.00		1.80	1.45	2.50	2.45	2.35
5		2.85	2.90	3.00	1.80	1.40	2.50	2.60	2.25
6		2.80	2.90	3.00	1.70	1.40	2.40	2.60	2.25
7		2.90	2.55	2.90	1.65	1.35	2.45	2.75	2.25
8		2.90	2.75	3.05	1.60	1.30	2.55	2.70	2.15
9		2.70	3.15	2.70	1.85	1.20	2.50	(a)	2.25
10		2.75		3.00	1.65	1.15	2.45		2.30
11		2.75	3.00	2.90	1.60	1.10	2.70		2.30
12		2.75	3.05	3.00	1.50	1.10	2.75		2.35
13		2.90	3.40	3.05	1.45	1.10	2.75		2.30
14		3.10	3.35	2.65	1.40	1.05	2.70		2.45
15	2.70	3.40	3.15	2.80	1.40	1.00	2.65		2.50
16	2.65	3.40	3.30	2.50	1.35	1.00	2.65		2.40
17	2.65	3.95	3.00	2.50	1.30	1.00	2.60		2.50
18	2.60	3.70	3.25	2.35	1.30	0.95	2.65		2.50
19	2.70	3.60	3.25	2.30	1.25	0.95	2.65		2.60
20	2.75	3.40	3.25	2.25	1.20	0.90	2.80		2.70

a Book stolen containing records from November 9.

Daily gage height, in feet, of Platte River near Lexington, Nebr.—Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
21	2.70	3.20	3.10	2.25	1.20	1.60	2.70	.....	2.65
22	2.60	3.35	3.35	2.15	1.20	2.10	2.60	.....	2.60
23	2.60	3.40	3.20	2.10	1.25	2.05	2.60	.....	2.70
24	2.75	3.30	3.40	2.05	1.30	2.25	2.60	.....	2.70
25	2.65	3.20	3.40	2.00	1.40	2.85	2.60	.....	2.80
26	2.60	3.20	3.10	2.40	1.45	2.35	2.60	.....	2.70
27	2.90	3.25	3.10	2.40	1.35	2.70	2.65	.....	2.80
28	2.70	3.30	(a)	2.35	1.30	2.70	2.80	.....	2.85
29	2.75	3.40	.....	2.15	1.25	2.40	2.65	.....	2.85
30	2.80	3.35	.....	2.40	2.15	2.45	2.70	.....	3.00
31	.....	3.30	.....	2.30	2.00	.....	2.70	.....	3.00

[a] Gage down; bridge being repaired.

Rating table for Platte River near Lexington, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.1	160	2.6	1,680	3.1	5,140	3.6	10,240
2.2	390	2.7	2,220	3.2	6,060	3.7	11,520
2.3	640	2.8	2,820	3.3	7,000	3.8	12,860
2.4	920	2.9	3,500	3.4	8,020	3.9	14,240
2.5	1,260	3.0	4,290	3.5	9,060	4.0	15,680

[a] This table was applied indirectly, according to the method outlined on p. 323, 19th An. Rept., U. S. Geol. Surv., Pt. IV.

Estimated monthly discharge of the Platte River near Lexington, Nebr.

[Drainage area, 53,300 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 15 to 30	.....	.....	2,208	70,072	0.041	0.024
May	14,672	1,950	5,490	337,550	.103	.119
June, 26 days	.....	.....	5,135	264,813	.096	.092
July	5,692	0	2,234	137,350	.042	.048
August	565	0	27	1,660	.001	.001
September	2,780	0	302	17,968	.006	.007
October	1,896	640	1,191	73,232	.022	.025
December	4,290	275	1,678	103,160	.031	.036

NORTH PLATTE RIVER AT NORTH PLATTE, NEBR.

The lowest gaging station on this river is located at the wagon bridge just north of North Platte, Nebr., and was established October 5, 1894. It is 3.5 miles above the junction with the South Platte River. The bridge is a long, low, pile bridge, having 93 spans of approximately 20 feet each, crossing the main channel of the river. North of this, at a distance of about 440 feet, is another bridge crossing a smaller branch or slough, and having six spans of about 20 feet each. The water, except in times of flood, does not pass under all of the spans of the long bridge. Usually the greater part flows under two or three of the spans, spreading out in shallow pools or streamlets under others. Beneath the greater number of spans is a dry, sandy bed at ordinary stages. The initial point for soundings is on the right bank and consists of a mark on the railing on the upstream side of the bridge. The channel is nearly straight for about 500 feet both above and below the station. The banks are low, but are rarely, if ever, overflowed.

The observations of river height are made at the Union Pacific Railroad bridge, about 2 miles below the wagon-road bridge. The railroad bridge is 3 miles above the junction of the North and South Platte rivers. The gage is vertical, marked to tenths of a foot, and is fastened by screws to the piling under the bridge. The top of the east rail directly over the gage is 12 feet above the zero. The gage rod is read twice each day by H. E. Dress, the railroad bridge watchman.

Discharge measurements of North Platte River at North Platte, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 9	H. O. Smith and B. E. Forbes	2.20	1,804
May 6	H. O. Smith	2.65	3,723
May 20	do	3.15	7,136
June 3	do	2.50	3,039
June 19	do	3.00	6,610
July 3	do	2.70	4,991
July 17	do	1.65	1,343
July 28	do	1.70	678
August 9	do	1.00	55
August 18	do	1.00	49
August 23	do	1.00	94
September 6	do	1.00	20
September 24	do	2.30	1,817
November 29	do	2.40	822

Rating table for North Platte River at North Platte, Nebr.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	15	1.5	565	2.5	2,950	3.5	11,100
.6	30	1.6	670	2.6	3,440	3.6	12,700
.7	50	1.7	800	2.7	4,050	3.7	14,300
.8	75	1.8	950	2.8	4,700	3.8	16,000
.9	100	1.9	1,120	2.9	5,450	3.9	17,700
1.0	150	2.0	1,320	3.0	6,100	4.0	19,400
1.1	210	2.1	1,560	3.1	6,900		
1.2	280	2.2	1,800	3.2	7,800		
1.3	370	2.3	2,150	3.3	8,800		
1.4	465	2.4	2,520	3.4	9,900		

[a] This table was applied indirectly according to the method outlined on p. 323, 19th An. Rept. U. S. Geol. Surv., Part IV.

Daily gage height, in feet, of North Platte River at North Platte, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.										
1	.....	2.00	2.70	2.60	2.80	1.50	1.10	1.90	2.00	2.20
2	.....	2.25	2.70	2.60	2.80	1.35	1.05	1.90	2.00	2.25
3	.....	2.30	2.60	2.50	2.70	1.20	1.00	1.90	2.00	2.30
4	.....	2.40	2.60	2.50	2.60	1.10	1.00	1.95	2.00	2.30
5	.....	2.40	2.70	2.45	2.50	1.10	1.00	2.00	2.00	2.30
6	.....	2.40	2.65	2.65	2.50	1.15	1.00	1.95	2.00	2.30
7	.....	2.25	2.60	2.95	2.50	1.00	1.00	1.90	2.00	(a)
8	.....	2.20	2.60	2.90	2.40	1.00	1.00	1.85	2.00	.....
9	.....	2.20	2.60	3.00	2.50	1.00	1.00	1.75	2.00	.....
10	.....	2.15	2.60	2.90	2.35	1.05	.95	1.70	2.00	.....
11	.....	2.10	2.60	2.75	2.30	1.00	1.00	2.05	2.00	.....
12	.....	2.00	2.75	3.05	2.20	.90	1.10	2.00	2.00	.....
13	.....	2.05	2.90	2.95	2.10	.90	1.15	2.00	2.00	.....
14	.....	2.15	2.90	3.00	2.00	1.05	1.10	2.00	2.00	.....
15	(a)	2.30	3.00	3.00	2.00	1.05	1.20	2.00	2.10	.....
16	1.80	2.40	3.40	3.00	1.75	1.00	1.15	2.00	2.10	.....
17	2.05	2.40	3.20	2.95	1.50	.90	1.10	2.00	2.10	.....
18	2.20	2.35	3.05	3.00	1.60	1.00	1.20	1.95	2.10	.....
19	2.20	2.40	3.10	3.00	1.70	1.10	1.15	1.90	2.10	.....
20	2.25	2.40	3.15	3.00	1.70	1.10	1.10	1.90	2.10	.....
21	2.30	2.40	3.15	2.90	1.70	1.00	1.20	2.00	2.05	.....
22	2.30	2.55	3.10	2.90	1.60	1.00	1.55	2.00	2.00	.....
23	2.35	2.60	3.10	2.90	1.60	1.00	2.25	2.00	2.05	.....
24	2.55	2.60	3.10	2.80	1.50	1.05	2.30	2.00	2.10	.....
25	2.60	2.60	3.10	2.65	1.40	1.10	2.15	2.00	2.10	.....
26	2.65	2.50	3.05	2.60	1.40	1.00	1.95	2.00	2.20	.....
27	2.50	2.60	3.00	2.60	1.45	1.00	1.95	2.00	2.60	.....
28	2.45	2.60	2.90	2.50	1.65	1.10	2.00	2.00	2.50	.....
29	2.30	2.60	2.90	2.50	1.80	1.20	2.00	1.90	2.40	.....
30	2.05	2.60	2.90	2.70	1.65	1.10	1.90	1.90	2.20	.....
31	2.00	.....	2.80	.....	1.50	1.10	.....	2.00	.....	.....

[a] River frozen.

Estimated monthly discharge of the North Platte River at North Platte, Nebr.

[Drainage area 28,517 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1901.						
March	9,900	1,320	3,260	200,425	0.110	0.130
April	4,700	1,560	2,408	143,276	.080	.090
May	14,300	2,150	7,680	472,232	.270	.310
June	17,700	4,050	9,733	579,108	.340	.380
July	4,050	75	1,508	92,712	.050	.060
August	800	50	346	21,275	.010	.010
September	1,320	565	1,068	63,546	.040	.040
October	1,320	670	1,121	68,919	.040	.050
November	1,800	1,320	1,576	93,772	.060	.070
1902.						
March 16 to 31			2,257	71,627	.079	.047
April	3,440	1,800	2,443	145,359	.086	.096
May	9,900	3,440	5,450	335,066	.191	.220
June	6,900	2,950	5,139	305,790	.180	.201
July	6,100	370	2,229	137,039	.078	.090
August	370	30	102	6,271	.004	.005
September	1,800	100	481	28,620	.017	.019
October	1,120	670	1,035	63,642	.036	.042
November	1,560	800	1,104	65,688	.039	.044

NORTH PLATTE RIVER AT BRIDGEPORT, NEBR.

This station was established May 4, 1902, by R. H. Willis. It is located at the wagon bridge, one-half mile due north from Bridgeport, Nebr. The gage is of the usual wire type, the scaleboard being graduated to half-tenths of feet. It is inclosed in a wooden box securely fastened to the railing of the bridge. When the gage reads zero the water is 9 feet below the floor of the bridge at the gage. The gage is read daily by Frank Churchill, a schoolboy who lives one-half mile away. The discharge measurements are made from the bridge, and the initial point for sounding is on the right bank at the south end of the west railing of the bridge. The channel widens both above and below the station. The banks are low, but not liable to overflow. The bed of the stream is sandy and shifting. The bench mark is the top of the floor of the bridge at the gage. Its elevation is 9 feet above the surface of the water when the gage reads zero.

The following discharge measurements were made by R. H. Willis and Frank Dobson in 1902:

May 20: Gage height, 6.00 feet; discharge, 5,414 second-feet.
June 3: Gage height, 5.80 feet; discharge, 4,515 second-feet.
June 10: Gage height, 5.17 feet; discharge, 2,050 second-feet.
June 14: Gage height, 5.97 feet; discharge, 5,433 second-feet.
June 21: Gage height, 5.71 feet; discharge, 5,120 second-feet.
July 19: Gage height, 5.00 feet; discharge, 787 second-feet.
July 26: Gage height, 4.87 feet; discharge, 619 second-feet.
August 8: Gage height, 4.68 feet; discharge, 190 second-feet.
August 28: Gage height, 4.49 feet; discharge, 37 second-feet.
September 22: Gage height, 5.08 feet; discharge, 634 second-feet.

Daily gage height, in feet, of North Platte River at Bridgeport, Nebr.

Day.	May.	June.	July	Aug.	Sept.	Oct.	Nov.
1902.							
1	.....	5.41	5.60	4.85	4.50	4.79	5.02
2	.....	5.61	5.56	4.75	4.46	4.75	4.95
3	.....	5.79	5.76	4.80	4.45	4.80	4.98
4	5.50	5.93	5.40	4.78	4.44	4.80	4.88
5	5.70	6.04	5.43	4.80	4.40	4.84	4.96
6	5.60	5.99	5.32	4.79	4.40	4.82	5.00
7	5.56	6.10	5.33	4.80	4.40	4.80	(a)
8	5.60	5.93	5.35	.....	4.40	4.82	.....
9	5.68	5.89	5.27	4.75	4.48	4.85	.....
10	.....	5.90	5.16	4.72	4.40	4.85	.....
11	.....	5.93	5.19	4.72	4.40	4.91	.....
12	5.76	5.92	5.10	4.70	4.40	4.95	.....
13	.....	5.89	5.02	4.67	4.40	4.90	.....
14	5.80	6.00	5.04	5.05	4.38	4.91	.....
15	5.89	6.04	5.00	4.75	4.41	4.94	.....
16	5.86	6.00	5.20	4.68	4.40	4.95	.....
17	5.91	6.00	5.04	4.70	4.40	4.92	.....
18	5.99	5.85	5.01	4.65	4.40	4.95	.....
19	5.95	5.82	5.00	4.62	.....	4.91	.....
20	6.00	5.82	4.89	4.61	4.46	4.92	.....
21	6.04	5.75	4.86	4.60	.....	.....	.....
22	6.10	5.68	4.80	4.59	4.95	4.94	.....
23	6.04	5.58	4.75	4.60	4.88	4.95	.....
24	6.04	5.48	4.77	4.62	4.78	4.95	.....
25	5.96	5.47	4.86	4.52	4.77	4.94	.....
26	5.86	5.26	4.90	4.52	4.95	4.95	.....
27	5.65	5.46	4.94	4.56	4.85	4.90	.....
28	5.56	5.60	4.79	4.60	4.82	4.91	5.00
29	5.41	5.87	4.76	.....	4.82	4.95	.....
30	5.45	5.85	4.85	.....	4.79	4.94	.....
31	5.41	.....	4.90	.....	.....	4.91	.....

a Observations discontinued November 6 to December 31 on account of ice.

Rating table for North Platte River at Bridgeport, Nebr., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.4	10	4.9	560	5.4	2,120	5.9	4,820
4.5	50	5.0	790	5.5	2,610	6.0	5,450
4.6	110	5.1	1,060	5.6	3,120	6.1	6,200
4.7	210	5.2	1,380	5.7	3,660		
4.8	350	5.3	1,710	5.8	4,230		

Estimated monthly discharge of the North Platte River at Bridgeport, Nebr.

[Drainage area, 23,190 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
May, 25 days	----------	----------	4,149	255,050	0.179	0.206
June	6,200	1,580	4,267	253,900	.184	.205
July	4,000	290	1,200	73,780	.052	.060
August, 27 days	----------	----------	244	15,000	.011	.013
September, 28 days	----------	----------	162	9,640	.007	.008
October, 30 days	----------	----------	559	34,372	.024	.028

NORTH PLATTE RIVER AT MITCHELL, NEBR.

This station was established by O. V. P. Stout on June 3, 1901. It replaces the station at Gering, Nebr., which was discontinued, as the narrower channel at Mitchell seemed favorable to increased accuracy of gagings, and, being nearer the Wyoming line, it serves better as a State-line gaging station.

The gage consists of a sash weight hung from a wire carrying an index reading on a horizontal rod nailed to the bridge rail. The zero of the gage is 8 feet below the bridge floor at the gage. It is also 6.73, 6.79, and 6.79 feet below the tops of the upstream ends of the bridge. The observer is G. D. Aughinbaugh, a barber at Mitchell, about one-half mile from the bridge.

On April 4, 1902, a temporary gage rod was set whose zero mark was 3.79 lower than the old rod of 1901. On May 3, 1902, a new permanent gage was put in whose zero mark was 1.0 foot lower than the old rod of 1901, in order to avoid negative gage heights. Hence, between April 4 and May 3, 1902, 2.79 feet were subtracted from the gage heights reported by the observer. To make the gage heights reported during 1901 comparable with those of 1902, 1.0 foot must be added.

Discharge measurements of North Platte River at Mitchell, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet*	*Sec.-feet.*
April 4	Frank Dobson	1.56	917
May 3	do	2.22	2,649
May 28	do	2.46	3,698
June 12	do	3.15	6,425
June 19	do	3.00	4,937
June 27	do	2.42	3,257
July 16	do	1.58	1,014
July 24	do	1.30	630
August 2	do	1.05	349
August 19	do	.85	102
September 2	do	.82	30
October 25	R. H. Willis	.96	363

Daily gage height, in feet, of North Platte River at Mitchell, Nebr.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1		2.26	2.79	2.30	1.21	0.82	0.86	0.95
2		2.36	2.91	2.65	1.23	.82	.86	.94
3	(a)	2.22	3.05	2.22	1.19	.83	.87	.94
4	1.56	2.42	3.17	2.05	1.13	.83	.87	.93
5	1.56	2.27	3.25	1.89	1.14	.82	.87	.94
6	1.56	2.32	3.27	1.91	1.14	.82	.87	1.08
7	1.31	2.43	3.05	1.90	1.00	.82	.93	1.09
8	1.21	2.47	3.05	1.91	1.03	.83		1.08
9	1.31	2.48	3.02	1.90	1.04	.83		1.08
10	1.27	2.65	3.17	1.85	1.00	.82		1.11
11	1.27	2.75	3.11	1.76	.98	.82		1.09
12	1.41	2.70	3.16	1.69	.95	.82	.89	1.10
13	1.51	2.80	3.14	1.69	.90	.82	.93	1.10
14	1.61	2.95	3.14	1.76	.93	.83	.93	1.10
15	1.71	3.01	3.19	1.61	.90	.83	.91	1.10
16	1.91	3.07	3.10	1.60	.87	.83	.93	1.14
17	1.81	3.14	3.05	1.54	.86	.83	.92	1.10
18	1.81	3.14	3.01	1.46	.85	.83	.91	1.75
19	1.86	3.19	3.03	1.41	.85	.82	.93	1.15
20	1.86	3.19	2.99	1.38	.85	.84	.93	1.18
21	1.91	3.02	2.94	1.37	.84	.85	.94	1.17
22	1.86	3.27	2.76	1.37	.84	.88	.96	1.16
23	1.86	3.19	2.64	1.39	.84	.89	.97	
24	2.26	3.15	2.51	1.33	.84	.85	.97	
25	2.21	3.05	2.32	1.28	.84	.84	.98	
26	2.41	2.90	2.21	1.31	.84	.85	.99	
27	2.41	2.70	2.30	1.29	.84	.84	.98	
28	2.51	2.52	2.20	1.25	.84	.87	.99	
29	2.46	2.49	2.53	1.46	.83	.86	1.00	
30	2.36	2.39	2.39	1.50	.83	.86	.99	
31		2.20		1.31	.83		.97	

a Observations discontinued from January 1 to April 4 and from November 22 to December 31 on account of ice.

Rating table for North Platte River at Mitchell, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	99	1.2	1,650	2.4	4,595	3.6	9,920
.2	235	1.4	2,020	2.6	5,290	3.8	11,022
.4	455	1.6	2,455	2.8	6,100	4.0	12,120
.6	720	1.8	2,910	3.0	7,015	.....	.....
.8	1,005	2.0	3,415	3.2	7,940	.....	.....
1.0	1,310	2.2	3,980	3.4	8,900	.....	.....

[a] This table was applied indirectly, according to the method outlined, p. 323, 19th An. U. S. Geol. Surv., Pt. IV.

Estimated monthly discharge of the North Platte River at Mitchell, Nebr.

[Drainage area, 24,400 square miles.]

Month.	Discharge (second-feet).			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 4 to 30	.....	.....	1,603	85,846	0.066	0.067
May	6,373	2,649	4,346	267,200	.178	.205
June	6,877	2,934	4,915	292,420	.201	.224
July	3,777	612	1,308	80,420	.054	.062
August	559	44	207	12,728	.008	.009
September	124	30	69	4,105	.003	.003
October, 24 days	.....	.....	299	14,233	.012	.011
November 1 to 22	.....	.....	563	24,567	.023	.019

NORTH PLATTE RIVER AT GUERNSEY, WYO.

This station was established June 14, 1900, by A. J. Parshall. It is located at the county bridge about a half mile northwest of Guernsey. The bridge has eight piers, the sides are planked, and there is uniform flow under each span. The rod consists of a 4-inch by 4-inch by 12-foot scantling firmly attached to one of the piers of the bridge. As the station was to be a temporary one, a metallic tape, divided into feet and tenths, was securely fastened to the rod. The bench mark is a spike driven into a sleeper of the bridge 1 foot from the rod and at an elevation of 10.04 feet above the zero. The channel is straight for a distance above and below the station. Both banks are high and do not overflow at high stages. The bed of the stream is sandy, but probably does not shift much.

It was found that considerable inconvenience was caused by sand accumulating about the rod as the high water subsided. With the opening of the season of 1902 a new rod was placed about 200 feet

above the first location. It was fastened to one of the piers of the railroad bridge, and was placed 1 foot lower in the water.

Measurements are still made from the county bridge, which, while it does not furnish a perfect location for measurements, is the best yet found on the river in Wyoming.

Discharge measurements of North Platte River at Guernsey, Wyo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 28	A. J. Parshall	0.90	1,099
April 4	do	.65	748
April 15	do	1.50	1,696
April 29	do	2.10	3,025
May 22	do	3.80	7,379
September 5	do	−.30	173
October 9	do	.20	437

Daily gage height, in feet, of North Platte River at Guernsey, Wyo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1	0.90	2.20	3.80	1.60	0.50	−0.20	0.20	0.30	0.40
2	.90	2.40	3.80	1.60	.50	−.20	.20	.30	.40
3	.65	2.40	3.80	1.60	.50	−.30	.20	.30	.40
4	.65	2.40	4.00	1.60	.50	−.30	.20	.30	.40
5	.65	2.60	4.00	1.80	.40	−.30	.20	.30	.40
6	.80	2.60	4.00	1.60	.40	−.25	.20	.30	.40
7	.80	2.80	4.00	1.20	.40	−.30	.20	.30	.40
8	.90	2.80	4.00	1.60	.40	−.30	.20	.30	.40
9	1.00	2.80	4.00	1.20	.20	−.30	.20	.30	.40
10	1.00	3.00	3.80	1.20	.40	−.30	.20	.30	.40
11	1.00	3.00	3.80	1.20	.40	−.30	.20	.30	.40
12	1.05	3.20	4.00	1.20	.20	.20	.20	.30	.30
13	1.25	3.20	4.00	1.00	.20	.20	.20	.30	.30
14	1.40	3.20	3.80	1.00	.20	−.30	.20	.30	.30
15	1.60	3.20	3.80	1.00	.20	−.20	.20	.30	.30
16	1.60	4.10	3.80	1.00	.00	.20	.20	.30	.60
17	1.60	3.80	3.40	.80	.00	.30	.20	.30	.60
18	1.50	4.00	3.40	.80	.00	.30	.20	.30	.60
19	1.60	3.80	3.40	.80	.00	.30	.20	.40	.60
20	1.60	3.80	3.00	1.00	.00	−.20	.20	.40	.60
21	1.60	3.80	3.00	1.00	.00	.20	.20	.40	.70
22	1.90	3.80	3.00	1.00	.00	.30	.20	.40	.70
23	2.00	3.80	2.60	.80	.00	−.30	.20	.40	.70
24	2.20	3.60	2.60	.80	−.10	.30	.20	.40	.75
25	2.20	3.00	2.60	.70	.10	−.30	.20	.40	.70
26	2.40	2.80	2.00	1.20	−.20	−.30	.20	.40	.70
27	2.20	2.60	2.00	1.20	.20	−.30	.20	.40	.70
28	2.20	2.60	2.00	1.20	−.20	−.30	.20	.40	.80
29	2.20	2.60	2.00	1.20	−.20	−.30	.30	.40	.80
30	2.20	3.00	2.00	.80	−.20	.20	.30	.40	.80
31	.....	3.00	.....	.80	−.20	.....	.30	.....	.80

Rating table for North Platte River at Guernsey, Wyo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.7	15	0.5	625	1.7	2,135	2.9	5,050
— .6	50	.6	700	1.8	2,335	3.0	5,305
— .5	90	.7	780	1.9	2,550	3.1	5,560
— .4	130	.8	870	2.0	2,780	3.2	5,820
— .3	175	.9	970	2.1	3,030	3.3	6,080
— .2	220	1.0	1,080	2.2	3,280	3.4	6,340
— .1	270	1.1	1,200	2.3	3,530	3.5	6,600
.0	320	1.2	1,330	2.4	3,780	3.6	6,860
.1	375	1.3	1,470	2.5	4,030	3.7	7,120
.2	430	1.4	1,620	2.6	4,285	3.8	7,380
.3	490	1.5	1,780	2.7	4,540	3.9	7,640
.4	555	1.6	1,950	2.8	4,795	4.0	7,900

Estimated monthly discharge of North Platte River at Guernsey, Wyo.

[Drainage area, 16,243 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	3,780	740	1,885	111,949	0.12	0.13
May	8,160	3,280	5,556	341,015	.34	.39
June	7,900	2,780	6,131	364,181	.38	.42
July	2,335	780	1,304	80,061	.08	.09
August	625	220	400	24,552	.02	.02
September	430	175	196	11,662	.01	.01
October	490	430	436	26,750	.03	.03
November	555	490	516	30,650	.03	.03
December	870	490	663	40,689	.04	.05

LITTLE LARAMIE RIVER NEAR HATTON, WYO.

This station was established in 1902 by B. P. Fleming. It is located at an old bridge 25 miles northwest of Laramie, Wyo. The gage is a plain staff graduated to feet and tenths and secured to the bridge. It is read twice daily by J. M. May, a ranchman, who lives about 75 yards from the gage. The initial point for soundings is a nail driven in the bridge stringer at the left bank. The channel is straight above the station and curved below. The water is quite swift. The right bank is liable to overflow. The left bank is high and rocky. There is an old channel at the right of the station in which there is flow at

high water. The bed of the stream is rocky and very rough. The bench mark is on a rock on the left bank of the stream near the gage. It is marked B. M. U. S. G. S. Its elevation above the zero of the gage has not been determined.

During 1902 the following discharge measurements were made by B. P. Fleming:

July 5: Gage height, 1.05 feet; discharge, 159 second-feet.
August 21: Gage height, 0.47 foot; discharge, 30 second-feet.
October 14: Gage height, 0.68 foot; discharge, 51 second-feet.

Daily gage height, in feet, of Little Laramie River near Hatton, Wyo.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Day.	July.	Aug.	Sept.	Oct.	Nov.
1902.											
1	.....	0.60	0.30	0.70	0.55	17	1.00	0.40	0.30	0.60	0.55
2	.....	.60	.30	.70	.55	18	1.15	.40	.30	.60	.60
3	.....	.60	.30	.70	.45	19	1.00	.35	.30	.60	.65
4	.....	.50	.30	.70	.45	20	.95	.30	.30	.60	.65
5	.....	.50	.30	.70	.45	21	.90	.35	1.20	.60	.70
6	1.00	.50	.30	.60	.45	22	.80	.30	1.25	.60	.65
7	1.00	.55	.20	.60	.45	23	.80	.30	1.00	.60	.65
8	.90	.55	.20	.60	.60	24	.80	.30	.80	.60	.60
9	.90	.55	.20	.60	.60	25	.80	.30	.80	.60	.65
10	.90	.40	.30	.60	.60	26	.80	.30	.80	.60	.60
11	.80	.45	.30	.70	.55	27	.80	.30	.80	.60	.55
12	.80	.55	.30	.70	.50	28	.75	.30	.70	.60	.55
13	.85	.50	.30	.70	.45	29	.65	.30	.75	.60	.60
14	.90	.50	.30	.70	.45	30	.60	.35	.70	.60	.60
15	.85	.55	.30	.70	.55	31	.65	.30	.....	.55	.....
16	.85	.45	.30	.60	.50						

Rating table for Little Laramie River near Hatton, Wyo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	2.5	0.4	24.5	0.7	54.5	1.0	133
.2	9.5	.5	32.5	.8	72.5	1.1	188
.3	16.5	.6	41.5	.9	96	1.2	248

Estimated monthly discharge of Little Laramie River near Hatton, Wyo.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
July 6–31	.....	.....	91	4,695
August	42	16	27	1,660
September	278	10	48	2,856
October	54	42	46	2,828
November	54	28	38	2,265

SWEETWATER RIVER AT DEVILS GATE, NEAR SPLITROCK, WYO.

This station was established in October, 1902, by W. W. Schlecht. It is located about one-fourth mile above Devils Gate and is reached by a team from Rawlins or from Casper, Wyo. The gage is of the usual wire type, with the scale board graduated to feet and tenths. It is read twice daily by Tom Sun, jr., a rancher who lives about 300 yards from the gage. The gagings are made temporarily from a foot bridge at Tom Sun's house. It is intended later to establish a cable at this point.

One discharge measurement made by W. W. Schlecht on October 4, 1902, gives gage height 4.02 feet; discharge, 14.5 second-feet.

Daily gage height, in feet, of Sweetwater River at Devils Gate, Wyo.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.											
1	4.05	.....	4.20	12	4.07	4.11	4.50	23	4.09	4.10	4.50
2	4.00	.....	4.10	13	4.06	4.11	4.50	24	4.09	4.05	4.55
3	4.02	.....	4.10	14	4.05	4.19	4.50	25	4.10	4.15	4.60
4	4.03	.....	4.40	15	4.04	4.14	4.40	26	.....	4.15	4.55
5	4.03	.....	4.40	16	4.03	4.00	4.40	27	.....	4.15	4.45
6	4.03	.....	4.50	17	4.06	4.05	4.10	28	.....	4.20	4.40
7	4.02	.....	4.10	18	4.07	4.00	4.40	29	.....	4.20	4.55
8	4.01	.....	4.15	19	4.05	4.05	4.45	30	.....	4.20	4.45
9	4.02	4.08	4.50	20	4.04	4.05	4.40	31	.....	.....	4.50
10	4.01	4.05	4.50	21	4.09	4.00	4.60				
11	4.03	4.10	4.50	22	4.09	4.10	4.50				

SOUTH PLATTE RIVER AT BIGSPRING, NEBR.

This station was established September 5, 1902, by J. C. Stevens. It is located on the highway bridge one-fourth mile south of Bigspring, Nebr. The gage is of the usual wire type, graduated to feet and tenths, and bolted to the girder of the bridge. It is read daily by Victor Root, a schoolboy, who lives near by. The measurements are made from the bridge, and the initial point for soundings is on the upstream side of the north end of the bridge. There is a short bend above the station and below the station the river is straight. The banks are not liable to overflow. The bed is sandy and shifting. The bench mark is a United States Geological Survey bench mark (marked "U. S. Geological Survey B. M. Elevation above sea, 3,370 feet"), located about 200 feet north of the Union Pacific depot, on the west side of the street. Its elevation is 3,370 feet above sea level. The elevation of the floor of the bridge over the zero mark of the gage is 3,373.95 feet. When the gage reads zero the surface of the water is 9.1 feet below the floor of the bridge over zero mark on the rod and 3,364.85 below bench mark described above.

Gage heights were taken of the water surface when there was no surface flow by digging in the sand.

Discharge measurements of South Platte River at Bigspring, Nebr.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
September 5	J. C. Stevens	1.00	0
September 23	H. O. Smith	1.65	173

Daily gage height, in feet, of South Platte River at Bigspring, Nebr.

Day.	Sept.	Oct.	Nov.	Day.	Sept.	Oct.	Nov.	Day.	Sept.	Oct.	Nov.
1902.											
1	.....	1.80	1.45	12	1.00	1.35	1.35	23	1.65	1.35	1.30
2	.....	1.80	1.45	13	1.00	1.35	1.30	24	1.50	1.25	1.30
3	.....	1.80	1.45	14	1.00	1.35	1.30	25	2.00	1.25	1.30
4	.....	1.80	1.45	15	1.00	1.30	1.30	26	2.40	1.20	1.35
5	1.00	1.60	1.40	16	1.00	1.35	1.30	27	2.15	1.25	1.35
6	1.05	1.60	1.30	17	1.10	1.35	1.30	28	1.90	1.25	1.30
7	1.00	1.60	1.25	18	1.10	1.25	1.30	29	1.80	1.25	1.45
8	1.00	1.50	1.25	19	1.15	1.25	1.30	30	1.80	1.25	(a)
9	1.00	1.50	1.25	20	1.20	1.25	1.35	31	.....	1.35	.....
10	1.00	1.50	1.25	21	Pools.	1.20	1.30				
11	1.00	1.35	1.25	22	2.00	1.30	1.30				

a Observations were discontinued November 29.

SOUTH PLATTE RIVER AT JULESBURG, COLO.

This station was established April 2, 1902, by John E. Field, at the wagon bridge crossing the South Platte River, about 1 mile southeast of Julesburg, Colo., a station at the junction of the main line and Denver branch of the Union Pacific Railroad. As this is the last station on the South Platte River in Colorado, and is also below all irrigation ditches in Colorado taking water from the South Platte, with the exception of one, it is of considerable importance for securing data relative to the flow of return waters as well as the natural flow in the main channel. However, the conditions at this station are not as desirable as they should be, owing to the great width of the channel and the general instability of the bed of the stream, features characteristic of the whole course of the South Platte River through this part of the State. The channel at this point is about one-half mile wide, and at low stages of the river it is badly broken up by islands, causing the stream to flow in several different channels. The banks are low, but do not overflow. The bed of the river is dry during the greater part of the year and is shifting and unstable, being composed entirely of sand and gravel.

Measurements are usually made by wading, but may be made from the wagon bridge at high-water stages. The observations are taken once daily by Lloyd Jenkins, who lives in Julesburg. The gage rod consists of a 2 by 4 inch timber 7 feet long, spiked in a vertical position to a piling on the downstream side of the bridge, about 150 feet from the north end. No bench mark has been established, but the rod is securely spiked to the piling and any change in the position of the rod is hardly possible. The initial point for sounding is the left or north bank.

The following discharge measurements were made during 1902 by J. E. Field, S. G. Lees, and R. W. Hawley:

April 2: Gage height, 1.30 feet; discharge, 35 second-feet.
October 10: Gage height, 1.58 feet; discharge, 133 second-feet.
November 8: Gage height, 1.15 feet; discharge, 31 second-feet.

Daily gage height, in feet, of South Platte River at Julesburg, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1	1.30	1.20	1.20	1.10	0.75	0.75	2.30	1.15	1.40
2	1.30	1.25	1.10	1.10	.75	.75	2.20	1.15	1.40
3	1.30	1.25	1.05	1.50	.75	.75	2.00	1.15	1.40
4	1.30	1.25	1.05	1.25	.80	.75	1.80	1.15	1.55
5	1.25	1.20	1.05	1.15	.80	.75	1.75	1.15	1.75
6	1.25	1.20	1.15	1.15	.80	.75	1.70	1.15	1.90
7	1.25	1.20	1.15	1.15	.75	.75	1.70	1.15	2.00
8	1.20	1.15	1.15	1.00	.75	.75	1.70	1.15	2.20
9	1.20	1.15	1.00	1.00	.75	.75	1.65	1.15	2.45
10	1.20	1.15	1.00	1.00	.75	.75	1.55	1.15	2.50
11	1.20	1.15	1.00	.90	.75	.75	1.50	1.15	2.50
12	1.20	1.30	1.60	.90	.75	.75	1.45	1.15	2.50
13	1.20	1.20	1.35	.90	.75	.75	1.40	1.15	2.60
14	1.45	1.20	1.25	.80	.75	.75	1.40	1.20	2.60
15	1.40	1.30	1.25	.80	.75	.75	1.35	1.20	2.60
16	1.30	1.25	1.20	.80	.75	.75	1.30	1.20	2.60
17	1.30	1.20	1.20	.80	.75	.75	1.25	1.20	2.60
18	1.25	1.15	1.10	.80	.70	.75	1.20	1.20	2.60
19	1.20	1.20	1.10	.80	.70	.75	1.20	1.20	2.70
20	1.20	1.30	1.10	.80	.70	.75	1.20	1.20	.....
21	1.25	1.20	1.10	.80	.80	1.20	1.20	1.20	2.75
22	1.30	1.15	1.00	.80	.80	1.90	1.25	1.20	2.80
23	1.40	1.15	1.00	.80	.80	1.90	1.25	1.20	2.80
24	1.30	1.10	.95	.80	.80	2.00	1.25	1.20	2.85
25	1.30	1.10	.95	.85	.80	2.00	1.20	1.20	2.90
26	1.25	1.25	.90	.85	80	2.10	1.20	1.25	(a)
27	1.20	1.25	1.00	1.75	.80	2.20	1.20	1.30	.....
28	1.20	1.25	1.10	1.00	.80	2.30	1.20	1.40	.....
29	1.20	1.20	1.10	.80	.75	2.30	1.20	1.40	.....
30	1.20	1.25	1.10	.80	.75	2.30	1.15	1.40	.....
31	.....	1.25	.....	.75	.75	.....	1.15	.....	.....

a Frozen.

Rating table for South Platte River at Julesburg, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	4	1.4	75	2.0	407	2.6	953
.9	9	1.5	105	2.1	488	2.7	1,058
1.0	15	1.6	144	2.2	573	2.8	1,167
1.1	23	1.7	195	2.3	662	2.9	1,280
1.2	35	1.8	258	2.4	755		
1.3	52	1.9	330	2.5	852		

Estimated monthly discharge of South Platte River at Julesburg, Colo.

[Drainage area, 20,598 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	89	35	46	2,737	0.0022	0.0025
May	52	23	37	2,275	.0017	.0020
June	144	9	28	1,666	.0014	.0016
July	225	2	19	1,168	.0010	.0012
August	4	0	3	184	.0001	.0001
September	662	2	153	9,104	.0074	.0083
October	662	28	129	7,932	.0063	.0073
November	75	28	37	2,202	.0018	.0020
December 1-25			761	37,736	.0369	.0343

MIDDLE CROW CREEK NEAR HECLA, WYO.

This station was established March 24, 1902, by A. J. Parshall. It is located 4 miles northwest of Hecla, Wyo., on a footbridge. The gage is attached to the timber of the bridge, and is graduated to hundredths of a foot. It is read twice daily by Hugh W. McGee. The initial point for sounding is on the left bank. The channel is straight above the station and curved below. The right bank is low and subject to overflow. The left bank is high and does not overflow. The bed of the stream is sandy. The bench mark is a notch cut in a tree 6 feet east of the gage. Its elevation is 4.1 feet above the zero of the gage.

Discharge measurements of Middle Crow Creek near Heela, Wyo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 24	A. J. Parshall	0.80	3
April 20	do	2.20	17
May 7	do	2.40	28
May 14	do	2.50	31
May 20	do	2.20	25
June 1	do	1.05	8

Daily gage height, in feet, of Middle Crow Creek near Heela, Wyo.

Day.	April.	May.	June.	July.	Day.	April.	May.	June.	July.
1902.					1902.				
1	0.80	2.45	1.15	0.73	17	1.00	1.80	0.55	0.30
2	.80	2.35	1.05	.73	18	1.35	1.80	.55	.48
3	.80	2.50	.90	.65	19	1.75	2.05	.55	.48
4	.80	2.50	.90	.60	20	2.10	2.10	.55	.67
5	.80	2.45	.85	.50	21	2.30	1.70	.60	.63
6	.80	2.35	.85	.50	22	1.65	1.57	.55	.50
7	.90	2.35	.87	.48	23	1.25	1.50	.50	.50
8	.95	2.38	.82	.45	24	1.35	1.43	.45	.43
9	1.05	2.30	.75	.45	25	1.40	1.32	.32	.40
10	1.15	2.35	.70	.45	26	1.40	1.35	.30	.40
11	1.25	2.40	.60	.48	27	1.55	1.62	.35	.40
12	1.40	2.35	.60	.43	28	1.85	1.70	.70	.47
13	1.40	2.27	.58	.40	29	1.90	1.40	1.12	.40
14	1.35	2.40	.55	.40	30	2.40	1.35	.90	.35
15	1.25	2.40	.58	.40	31		1.20		.30
16	1.05	2.10	.60	.40					

Rating table for Middle Crow Creek near Heela, Wyo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
.0		0.7	4.5	1.4	13.5	2.1	24.0
0.1	0.5	.8	5.5	1.5	15.0	2.2	25.5
.2	1.0	.9	6.5	1.6	16.5	2.3	27.0
.3	1.5	1.0	7.5	1.7	18.0	2.4	28.5
.4	2.0	1.1	9.0	1.8	19.5	2.5	30.0
.5	2.5	1.2	10.5	1.9	21.0	2.6	31.5
.6	3.5	1.3	12.0	2.0	22.5	2.7	33.0

Estimated monthly discharge of Middle Crow Creek near Hecla, Wyo.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
April	28.5	5.5	12.6	750
May	30.0	10.5	22.4	1,375
June	9.8	1.5	4.4	263
July	4.8	1.5	2.6	161

SOUTH PLATTE RIVER AT KERSEY, COLO.

This station was established April 27, 1901, at Kersey, a station on the Union Pacific Railroad, about 6 miles east of Greeley, at a bridge 1½ miles north of the railroad station itself. This station was intended to take the place of the one previously maintained at Orchard, Colo. This point was selected on account of the regularity of the channel and the fact that there was a wagon bridge crossing the river from which gagings could be made at high water. It is of particular value owing to the fact that the point is just below all the important tributaries of the South Platte, which derive their supply from the mountain region. It is also at about the point where water could be used to the best advantage for storage in reservoirs along South Platte River in northeastern Colorado. The observer is Edward K. Plumb, who lives near the bridge and reads the rod daily. The gage rod consists of a vertical 2 by 6 inch timber, 8 feet long, marked in feet and tenths and spiked to the downstream side of the third pile of the bridge from its south end. The initial point for soundings is the right bank, downstream side, the bridge being marked every 10 feet. The right bank is high and not liable to overflow, but the left is low and water spreads over a considerable distance at high stages.

The following discharge measurements were made during 1902 by J. E. Field and R. W. Hawley:

January 3: Gage height, 2.65 feet; discharge, 634 second-feet.
February 28: Gage height, 2.70 feet; discharge, 700 second-feet.
April 2: Gage height, 1.85 feet; discharge, 328 second-feet.
August 15: Gage height, 1.30 feet; discharge, 62 second-feet.
November 2: Gage height, 1.65 feet; discharge, 188 second-feet.

Daily gage height, in feet, of South Platte River at Kersey, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.85	3.50	2.70	1.85	1.10	1.60	2.50	1.30	1.30	2.00	1.75	2.30
2	2.85	3.50	2.65	1.85	1.10	1.50	1.60	1.30	1.40	2.00	1.80	2.30
3	2.85	3.50	2.65	1.85	1.10	1.50	1.50	1.30	1.40	2.00	1.80	2.30
4	2.85	3.50	2.65	1.85	1.50	1.40	1.50	1.30	1.40	2.00	1.80	2.30
5	2.75	3.20	2.65	1.85	1.75	1.40	1.40	1.30	1.40	2.00	1.80	2.30
6	2.75	2.90	2.60	1.75	1.50	1.40	1.40	1.30	1.40	2.00	1.80	2.30
7	2.70	2.70	2.60	1.75	1.20	1.40	1.40	1.30	1.40	2.00	1.80	2.30
8	2.70	2.65	2.60	1.60	1.20	1.40	1.50	1.30	1.40	1.95	1.80	2.30
9	2.65	2.60	2.60	1.60	1.20	1.40	1.60	1.30	1.40	1.95	1.80	2.30
10	2.60	2.60	2.55	1.55	1.20	1.40	1.60	1.30	1.40	1.95	1.80	2.30
11	2.60	2.60	2.55	1.50	1.30	1.40	1.80	1.30	1.40	1.95	1.80	2.30
12	2.60	2.70	2.50	1.45	1.30	1.40	1.60	1.30	1.40	1.95	1.80	2.30
13	2.55	2.75	2.50	1.40	1.30	1.40	1.50	1.30	1.40	1.90	1.80	2.30
14	2.55	2.90	2.40	1.35	1.30	1.40	1.40	1.30	1.40	1.80	1.80	2.35
15	2.50	2.80	2.30	1.30	1.30	1.35	1.40	1.30	1.40	1.75	1.80	2.35
16	2.50	2.80	2.30	1.25	1.30	1.30	1.30	1.30	1.40	1.75	1.80	2.40
17	2.50	2.80	2.25	1.25	1.30	1.30	1.30	1.30	1.40	1.65	1.80	2.45
18	2.50	2.80	2.25	1.25	1.30	1.30	1.30	1.30	1.40	1.60	1.90	2.50
19	2.50	2.80	2.25	1.20	1.30	1.30	1.30	1.30	1.40	1.60	2.00	2.50
20	2.50	2.80	2.20	1.20	1.40	1,30	1.30	1.30	1.40	1.60	2.20	2.50
21	2.60	2.80	2.15	1.20	1.40	1.30	1.30	1.30	1.40	1.65	2.40	2.50
22	2.60	2.80	2.10	1.10	1.40	1.30	1.30	1.30	4.50	1.65	2.40	2.60
23	2.60	2.80	2.00	1.10	1.40	1.30	1.30	1.30	4.00	1.70	2.35	2.60
24	2.65	2.75	2.00	1.10	1.40	1.30	1.30	1.30	3.50	1.70	2.30	2.60
25	2.85	2.75	2.00	1.10	1.40	1.30	1.30	1.40	2.40	1.70	2.30	2.55
26	3.50	2.70	2.00	1.10	1.40	1.35	1.30	1.40	2.00	1.70	2.30	2.55
27	3.50	2.70	2.00	1.10	1.40	1.35	1.30	1.40	2.00	1.70	2.30	2.55
28	3.50	2.70	1.90	1.10	1.45	1.35	1.30	1.40	2.20	1.70	2.30	2.50
29	3.50	.....	1.90	1.10	1.50	1.35	1.30	1.40	2.10	1.70	2.30	2.45
30	3.50	.....	1.90	1.10	1.50	3.75	1.30	1.40	2.00	1.70	2.30	2.40
31	3.50	.....	1.90	.....	1.60	.....	1.30	1.30	.....	1.75	.....	2.40

Rating table for South Platte River at Kersey, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet*	*Second-feet.*
0.2	2	1.4	105	2.6	637	3.8	1,965
.4	4	1.6	170	2.8	770	4.0	2,261
.6	8	1.8	243	3.0	935	4.2	2,557
.8	14	2.0	325	3.2	1,139	4.4	2,853
1.0	29	2.2	423	3.4	1,386		
1.2	59	2.4	527	3.6	1,669		

Estimated monthly discharge of South Platte River at Kersey, Colo.

[Drainage area, 9,470 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches
1902.						
January	1,524	580	836	51,404	0.0883	0.101
February	1,524	637	862	47,873	.0910	.095
March	700	282	486	29,883	.0513	.059
April	262	42	122	7,259	.0129	.014
May	224	42	96	5,903	.0111	.013
June	1,891	80	158	9,402	.0167	.019
July	580	80	124	7,624	.0131	.015
August	105	80	85	5,226	.0090	.010
September	2,631	80	363	21,600	.0383	.043
October	325	170	249	15,310	.0263	.030
November	527	224	334	19,874	.0353	.039
December	637	475	532	32,711	.0562	.065
The year	2,631	42	354	254,069	.0375	.503

BIG THOMPSON CREEK NEAR ARKINS, COLO.

This stream drains the country immediately north of that drained by the headwaters of St. Vrain Creek, and is one of the largest tributaries of South Platte River, into which it empties about 4 miles above the town of Evans. Little Thompson Creek is an important tributary of Big Thompson Creek, and the country drained by these two streams makes up irrigation district No. 4. The junction of these creeks is near the lower end of the district, a short distance above the point where their combined waters enter the South Platte.

Records of the flow of this stream were begun in April, 1888. The station was established at its present location on April 1, 1899. The only diversion above the gaging station is Handy ditch, a record of the gage heights of which is kept by the water commissioner of that district, J. M. Wolaver, who also kept the records of Big Thompson Creek at this point during the year 1900. It is necessary to include the discharge of Handy ditch in order to obtain the total run-off of the basin. The rod is a vertical 2-inch by 4-inch timber fastened to the downstream side of the right-hand end of the wagon bridge on the ranch of John Chasteen. The bench mark is 25 feet south of the gage, and is a nail in the root of a cottonwood stump, the head of the nail being 9.35 feet above the zero of the gage. The channel of the stream is lined with bowlders and is very rough, but, not being

likely to change, it furnishes a good point for obtaining accurate measurements. A permanent station could be located here to advantage. Like the other tributaries of the South Platte, nearly all of the normal flow of Big Thompson and Little Thompson creeks is used for irrigation, and during the high-water stages the greater part of the volume is diverted into large reservoirs, from which it is used to advantage later in the season.

The following discharge measurements were made during 1902 by J. E. Field and M. C. Hinderlider:

August 30: Gage height, 0.75 feet; 86 second-feet.
November 14: Gage height, 0.42 feet; 28 second-feet.

Daily gage height, in feet, of Big Thompson Creek near Arkins, Colo.[a]

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1902.						
1		2.10	1.40	0.80	0.60	0.80
2		2.00	1.20	.80	.60	1.10
3		1.80	1.30	.80	.60	.90
4		2.00	1.30	.90	.60	1.00
5		2.20	1.20	.90	.50	.80
6		2.00	1.10	.80	.50	.80
7		2.00	1.00	.80	.50	.70
8		2.20	1.00	.80	.50	.70
9		2.20	.90	.80	.50	.70
10		2.30	1.00	.70	.50	.70
11		2.20	1.00	.70	.50	.80
12		2.00	1.00	.70	.50	1.00
13		1.90	1.00	.70	.50	.90
14		1.90	1.00	.80	.50	.90
15		2.00	1.00	.80	.50	.80
16		1.90	1.00	.70	.40	.80
17		1.80	1.00	.70	.40	.70
18		1.70	1.60	.70	.40	.80
19		1.60	1.40	.70	.40	.70
20		1.60	1.10	.70	.50	.70
21		1.60	1.00	.60	1.00	.70
22		1.60	1.00	.60	1.20	.60
23		1.50	1.00	.70	1.10	.60
24		1.60	1.00	.70	.90	.60
25	0.90	1.60	.90	.70	.80	.60
26	1.20	1.60	1.00	.60	1.10	.50
27	1.50	1.50	.90	.60	1.00	.50
28	2.00	1.60	.80	.60	.90	.60
29	1.60	1.70	.80	.60	.90	.60
30	2.00	1.50	.80	.70	.80	.60
31	2.10		.80	.60		.50

[a] To secure total discharge of Big Thompson Creek in figuring run-off, etc., add number of second-feet flowing in Handy Ditch for corresponding dates.

Rating table for Big Thompson Creek near Arkins, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	1	0.8	96	1.4	271	2.0	539
.3	12	.9	118	1.5	310	2.1	593
.4	26	1.0	143	1.6	350	2.2	650
.5	41	1.1	172	1.7	393	2.3	710
.6	58	1.2	203	1.8	439		
.7	76	1.3	236	1.9	486		

Estimated monthly discharge of Big Thompson Creek near Arkins, Colo.[a]

[Drainage area, 305 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	35	20	29	1,726	0.10	0.11
May	659	80	299	18,385	.98	1.13
June	773	310	505	30,050	1.66	1.85
July	385	108	182	11,191	.60	.69
August	130	67	90	5,534	.30	.35
September	238	34	89	5,296	.29	.32
October	198	46	98	6,026	.32	.37

[a] The discharge of Handy Ditch is included.

ST. VRAIN CREEK AT LYONS, COLO.

The town of Lyons is situated between the north and south forks of St. Vrain Creek, the forks uniting at a point about 1 mile east of the center of the town. Records of the flow of the creek at or near Lyons have been kept since April, 1888, except during the years 1893 and 1894, but the station was not put in its present condition until May 5, 1899, since which date records have been kept throughout each irrigation season. The present station is located one-half mile southeast of Lyons, Colo., below the junction of the north and south forks of St. Vrain Creek. The supply ditch takes water out on the left side of the stream above the gage. To obtain the total run-off of the drainage basin of the creek at this station, the amount of water in the ditch must be added to the discharge of the creek. The gage is an inclined 2 by 4 inch timber, graduated to vertical tenths of a foot,

the space between the marks being 0.134 of a foot. It is fastened to posts driven into the ground. The right bank of the stream is low and liable to overflow. The left bank is a railroad embankment and is not liable to overflow. Measurements are usually made by wading, but at high water they can be made from a wagon bridge 400 feet below the gage. The bench mark is a spike driven into the root of a large cottonwood tree, 150 feet north of the gage rod. The head of the spike is 6.51 feet above gage datum. The observer during 1902 was L. H. Dickson, commissioner of the St. Vrain water district, who read the gage during the irrigation season.

During 1902 the following discharge measurements were made by J. E. Field and M. C. Hinderlider:

July 28: Gage height, 2.50 feet; discharge, 91 second-feet.
August 30: Gage height, 2.05 feet; discharge, 31 second-feet.
November 8: Gage height, 2.08 feet; discharge, 40 second-feet.

Daily gage height, in feet, of St. Vrain Creek at Lyons, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	1.60	2.35	3.35	2.72	2.32	2.18	2.45	2.05
2	1.60	2.40	3.15	2.70	2.30	2.10	2.50	2.05
3	1.70	2.50	3.10	2.75	2.45	2.10	2.50	2.05
4	1.82	2.50	3.28	2.67	2.50	2.10	2.50	2.05
5	1.80	2.55	3.32	2.70	2.42	2.05	2.50	2.05
6	1.85	2.55	3.30	2.60	2.45	2.02	2.50	2.05
7	1.90	2.58	3.35	2.50	2.30	2.00	2.40	.....
8	2.00	2.70	3.45	2.45	2.35	2.00	2.35	.....
9	2.10	2.80	3.55	2.51	2.25	2.00	2.30	.....
10	2.00	2.90	3.45	2.58	2.20	2.00	2.30	.....
11	1.80	3.10	3.35	2.56	2.18	2.00	2.40	.....
12	1.80	3.20	3.35	2.51	2.18	2.03	2.35	.....
13	1.85	3.20	3.30	2.47	2.18	2.00	2.35	.....
14	1.90	3.25	3.30	2.50	2.20	2.00	2.35	.....
15	1.80	3.35	3.38	2.53	2.20	1.95	2.30	.....
16	1.85	3.22	3.25	2.54	2.20	1.95	2.25	.....
17	1.95	3.18	3.22	2.64	2.30	1.95	2.25	.....
18	2.00	3.10	3.15	2.80	2.20	1.95	2.22	.....
19	2.10	2.90	3.20	2.80	2.15	1.95	2.20	.....
20	2.15	2.85	3.20	2.60	2.12	1.95	2.15	.....
21	2.25	2.70	2.95	2.52	2.10	2.30	2.12	.....
22	2.10	2.60	2.95	2.50	2.10	3.00	2.15	.....
23	2.05	2.55	2.92	2.48	2.15	2.95	2.10	.....
24	2.07	2.55	2.98	2.43	2.18	2.55	2.20	.....
25	2.05	2.60	2.92	2.48	2.18	2.55	2.20	.....
26	2.07	3.00	2.95	2.50	2.08	2.60	2.10	.....
27	2.05	3.20	2.92	2.52	2.18	2.40	2.10	.....
28	2.15	3.20	2.95	2.45	2.10	2.40	2.10	.....
29	2.25	3.10	3.00	2.32	2.10	2.55	2.08	.....
30	2.25	3.30	2.78	2.50	2.05	2.50	2.05	.....
31	.....	3.50	.....	2.25	2.25	.....	2.05	.....

Daily gage height, in feet, of Supply ditch at Lyons, Colo.[a]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	0.21	0.25	1.30	0.65	0.55	0.25	0.40	0.40
2	.21	.25	1.35	.60	.25	.25	.40	.40
3	.23	.25	.92	.65	.25	.25	.50	.40
4	.25	.25	.50	.70	.25	.25	.50	.25
5	.25	.25	.68	.25	.25	.25	.50	.25
6	.25	.25	.72	.25	.25	.25	.50	.25
7	.25	.20	.70	.25	.25	.20	.50	.25
8	.25	.20	.75	.25	.25	.20	.40	.25
9	.25	.25	.85	.25	.35	.20	.40	.25
10	.41	.25	.85	.25	.45	.20	.40	.25
11	.25	.45	.70	.38	.45	.25	.40	.25
12	.25	.45	.55	.48	.45	.25	.40	.25
13	.25	.70	.50	.45	.45	.25	.40	.25
14	.25	.70	.50	.45	.35	.25	.40	.25
15	.25	.80	.82	.25	.25	.25	.40	.25
16	.25	.80	.80	.25	.25	.25	.40	.25
17	.25	.80	.75	.25	.25	.25	.40	.25
18	.25	.80	.75	.25	.25	.25	.40	.25
19	.25	.80	.75	.25	.25	.25	.40	.25
20	.25	.50	.70	.25	.25	.25	.40	.....
21	.25	.50	.70	.25	.25	.25	.40	.....
22	.25	.50	.70	.40	.25	.25	.50	.....
23	.25	.45	.55	.40	.25	.60	.20	.....
24	.25	.45	.50	.40	.25	.60	.20	.....
25	.25	.45	.50	.25	.25	.50	.40	.....
26	.25	.20	.50	.25	.40	.40	.40	.....
27	.25	.60	.40	.25	.45	.40	.40	.....
28	.25	.80	.30	.40	.40	.40	.40	.....
29	.25	.80	.25	.55	.40	.40	.40	.....
30	.25	.80	.25	.68	.40	.40	.40	.....
31	.....	1.20	.....	.50	.45	.....	.40	.....

[a] The daily flow of Supply ditch to be added to St. Vrain Creek at gaging station to give total discharge of St. Vrain Creek used in working up run-off, etc.

Rating table for St. Vrain Creek at Lyons, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.1	1	1.8	18	2.5	91	3.2	280
1.2	2	1.9	24	2.6	109	3.3	321
1.3	3	2.0	31	2.7	130	3.4	365
1.4	4	2.1	39	2.8	153	3.5	413
1.5	6	2.2	48	2.9	180	3.6	463
1.6	9	2.3	59	3.0	211	3.7	514
1.7	13	2.4	74	3.1	245	3.8	569

Estimated monthly discharge of St. Vrain Creek at Lyons, Colo.[a]

[Drainage area, 209 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	57	12	34	2,023	0.16	0.18
May	500	70	215	13,220	1.03	1.19
June	485	152	312	18,565	1.49	1.66
July	167	69	112	6,887	.54	.62
August	95	43	59	3,628	.28	.32
September	329	31	74	4,403	.35	.39
October	107	42	69	4,243	.33	.38
November 1–19	.....	.....	84	3,165	.40	.28

[a] This includes the flow of the supply ditch.

CLEAR CREEK AT FORKSCREEK, COLO.

The gaging station is located at the Forkscreek railroad station on the Colorado and Southern Railway, in Clear Creek canyon, just below the junction of the North and South Forks of Clear Creek. It was established May 29, 1899, and has been continued through the irrigation seasons of 1899, 1900, 1901, and 1902. The gage consists of a weight fastened to a wire running over a pulley fastened to the wall at the railway station. Bench mark No. 1 is a point on the timber to which the pulley is attached, and is 13.58 feet above gage datum. Bench mark No. 2 is a granite point 49.5 feet east of the first bench mark, and is 15.46 feet above gage datum. In May, 1902, a trussed foot bridge 48 feet long was placed across the creek at right angles to the direction of the current just below the railway bridge and about 300 feet below the forks of the creek. This bridge is located over the most desirable cross section of the stream, and where satisfactory measurements can be made. It is possible to secure fairly good results by means of measurements made at two bridges above the forks. At low water the stream is gaged by wading. The stream flows rapidly through this part of the canyon, the channel being rocky and the fall great. Both banks are high and rocky. The observer is C. A. Jones.

The following discharge measurements were made during 1902 by S. G. Lees and M. C. Hinderlider:

June 14: Gage height, 2.90 feet; discharge, 655 second-feet.
September 10: Gage height, 1.50 feet; discharge, 60 second-feet.
September 20: Gage height, 1.60 feet; discharge, 55 second-feet.
October 15: Gage height, 1.80 feet; discharge, 82 second-feet.

Daily gage height, in feet, of Clear Creek at Forkscreek, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	.....	2.10	3.05	2.60	1.90	1.60	1.80
2	.....	2.20	2.95	2.60	1.90	1.70	1.80
3	.....	2.40	2.95	2.55	1.90	1.70	1.80
4	.....	2.40	2.95	2.50	1.90	1.60	1.80
5	.....	2.30	3.00	2.50	1.90	1.60	1.75
6	.....	2.55	3.00	2.45	1.90	1.50	1.70
7	.....	2.60	3.00	2.40	1.90	1.50	1.70
8	.....	2.65	3.05	2.30	1.90	1.50	1.70
9	.....	2.65	3.15	2.30	1.80	1.50	1.70
10	.....	2.70	3.15	2.30	1.85	1.50	1.70
11	.....	2.75	3.30	2.25	1.90	1.55	1.70
12	.....	2.75	3.05	2.30	1.90	1.60	1.70
13	1.65	2.70	2.95	2.20	1.90	1.60	1.60
14	1.65	2.77	2.95	2.15	1.90	1.55	1.70
15	1.65	2.80	2.95	2.15	1.80	1.65	1.70
16	1.75	2.90	2.90	2.35	1.80	1.60	1.70
17	1.70	2.90	2.85	2.40	1.80	1.55	1.70
18	1.75	2.70	2.78	2.40	1.80	1.55	1.60
19	1.80	2.75	2.75	2.30	1.75	1.60	1.60
20	.....	2.65	2.75	2.30	1.70	1.65	1.60
21	.....	2.70	2.75	2.20	1.60	2.05	1.60
22	.....	2.55	2.70	2.10	1.60	1.90	1.60
23	.....	2.55	2.70	2.10	1.65	1.75	1.60
24	.....	2.40	2.65	2.10	1.80	1.75	1.60
25	.....	2.55	2.65	2.10	1.80	1.80	1.60
26	.....	2.70	2.60	2.10	1.80	1.75	1.60
27	1.60	2.95	2.70	2.10	1.80	1.70	1.60
28	1.70	2.75	2.75	2.05	1.70	1.70	1.60
29	1.75	2.80	2.75	2.00	1.70	1.90	1.50
30	2.05	2.80	2.60	2.00	1.70	1.80	.....
31	.....	2.90	.....	2.00	1.65	.....	.....

Rating table for Clear Creek at Forkscreek, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.3	20	2.2	179	3.1	480	4.0	946
1.4	32	2.3	205	3.2	522	4.1	1,003
1.5	44	2.4	235	3.3	566	4.2	1,060
1.6	58	2.5	267	3.4	614	4.3	1,117
1.7	75	2.6	299	3.5	665	4.4	1,174
1.8	93	2.7	332	3.6	719	4.5	1,231
1.9	112	2.8	367	3.7	775	4.6	1,288
2.0	133	2.9	403	3.8	832	4.7	1,345
2.1	155	3.0	441	3.9	889	4.8	1,402

Estimated monthly discharge of Clear Creek at Forkscreek, Colo.

[Drainage area, 345 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 13–19, 27–30	.....	.....	81	1,766	0.23	0.09
May	422	155	315	19,369	.91	1.05
June	566	299	398	23,683	1.15	1.28
July	299	133	199	12,236	.58	.67
August	112	58	94	5,780	.27	.31
September	144	44	69	4,106	.20	.22
October 1–29	.....	.....	70	4,026	.20	.22

SOUTH PLATTE RIVER AT DENVER, COLO.

In the spring of 1895 a river station was established at the Twenty-third Street Viaduct in the city of Denver, but observations were discontinued on June 18, as the location was found to be unfavorable for accurate measurements, and the water had fallen below the gage. In July a station was established at the Fifteenth Street Bridge and observations were begun, these being made in the morning and in the afternoon. Stream measurements are made from the lower side of the bridge. The original gage consisted of two 6 by 2 inch timbers spiked together, inclined and graduated to vertical tenths of a foot. The space between the marks was 0.156 foot. The timbers were fastened to posts driven into the bank. The bench mark is 107 feet southwest from the gage and is a cross mark on top of the east abutment of the Fifteenth Street Bridge on the north corner. It is marked B. M. and is 6.15 feet above the 9-foot mark of the gage rod.

Another inclined gage rod reading the same as the one on the right bank was placed on the left side in August, 1898. It consisted of a 4 by 4 inch by 12-foot timber fastened to posts driven into the left bank and graduated to vertical feet and tenths.

This rod was washed out by the high water of June, 1900, which also removed the sand bar in front of the rod on the right-hand side, making it available at low-water stages, and since that time the readings have been taken from the latter rod.

The initial point for soundings is on the right bank at the post of the iron railing. The channel is straight for about 1,000 feet above and below and the water moves with moderate velocity. The bed of the stream is sandy and shifting. This point is immediately below the

mouth of Cherry Creek, which enters between the Fourteenth Street and Fifteenth Street bridges. The stream at this point is confined between artificial embankments of furnace slag.

May 15, 1901, a T-rail was placed on the site of the latter rod, which was stolen. The rail was embedded in an inclined position in the slag bank. The zero of the rod is 12 feet below the top of the capstone of the southeast abutment of the Sixteenth Street Viaduct 100 feet northeast of the rod. All readings were taken from this rod from May 15, 1901, to June 9, 1903, when the rod was again stolen. On June 10, 1903, a vertical 4 by 4 inch timber was placed at the same point and fastened to a cottonwood tree. The zero of the rod was placed at the same elevation as the zero of the old gage. The observer is J. A. Banning, water commissioner.

Discharge measurements of South Platte River at Denver, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
April 1	J. E. Field	1.10	107
May 15	do	1.65	241
May 29	do	2.22	557
June 10	S. G. Lees	1.00	74
June 11	do	.98	62
June 12	do	1.05	68
June 13	do	1.85	163
June 16	do	1.00	63
July 16[a]	do	1.09	18
July 22	do	1.13	32
September 9	M. C. Hinderlider	1.10	22
September 12	do	1.00	16
October 14	do	1.30	63
October 28	R. W. Hawley	1.19	48
October 29	do	1.12	42

[a] Channel changed.

Daily gage height, in feet, of South Platte River at Denver, Colo.

Day.	Apr.	Oct.	Nov.	Dec.	Day.	Apr.	Oct.	Nov.	Dec.
1902.					1902.				
1	1.10	.....	1.20	.....	17	1.05	1.30	.....	1.10
2	1.09	.....	1.20	.....	18	1.00	1.30	.....	1.05
3	1.10	.....	1.20	.....	19	1.04	1.20	.....	1.03
4	1.02	.....	1.20	.....	20	.....	1.30	.....	1.20
5	1.04	.....	1.10	.....	21	.....	1.30	.....	1.40
6	1.16	1.22	1.10	.....	22	.....	1.30	.....	1.13
7	1.00	1.24	1.00	.....	23	.....	1.30	.....	1.20
8	.95	1.24	1.00	1.40	24	.....	1.20	.....	1.20
9	1.02	1.21	1.20	1.25	25	.....	1.20	.....	1.35
10	1.05	.....	1.10	1.20	26	.....	1.20	.....	1.30
11	1.02	.....	1.00	1.30	27	.....	1.20	.....	1.45
12	1.07	.....	1.00	1.12	28	.....	1.20	.....	1.45
13	1.08	.....	1.00	1.20	29	.....	1.20	.....	1.15
14	1.08	1.30	1.00	1.20	30	.....	1.20	.....	1.10
15	1.08	1.25	1.20	1.15	31	.....	1.20	.....	1.10
16	1.07	1.30	.....	1.10					

Rating table for South Platte River at Denver, Colo., for 1902.

JANUARY 1 TO JUNE 30, 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	2	0.9	48	1.2	106	1.5	187
.7	16	1.0	64	1.3	130	1.6	224
.8	32	1.1	83	1.4	156	1.7	270

JULY 1 TO DECEMBER 31, 1902.

0.8	2	1.2	56	1.6	221	2.0	435
.9	6	1.3	90	1.7	270	2.1	491
1.0	13	1.4	131	1.8	323	2.2	547
1.1	30	1.5	174	1.9	379		

Estimated monthly discharge of South Platte River at Denver, Colo.

[Drainage area, 3,840 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 1–19	.....	.....	74	2,789	0.019	0.013
October 6–31	.....	.....	71	3,661	.018	.017
November 1–15	.....	.....	32	952	.008	.004
December 8–31	.....	.....	61	3,046	.016	.015

BEAR CREEK NEAR MORRISON, COLO.

Bear Creek is one of the smaller tributaries of the South Platte, heading in the vicinity of Mount Evans, about 30 miles southwest of Denver, and entering the main stream about 8 miles above that city. Although usually of small volume, the stream drains a considerable portion of very mountainous country, which is subject to more or less violent cloudbursts, so that floods sometimes come down this creek, causing great destruction to property and even loss of life. All of the normal flow of the stream is used for irrigation, and it is only during high-water stages that a large amount of water passes through it. Records of its flow have been kept for a portion of each irrigation season since April, 1888, with the exception of the years 1892, 1893, and 1894. The present station was established April 1, 1899. It is located just above the town of Morrison. The gage rod, which is a 2-inch by 6-inch timber placed vertically and marked in feet and tenths, is fastened to the upper side of the dam which diverts water into the mains of the Denver Union Water Company. The bench mark is the top of a granite bowlder about 100 feet above the rod on the left-hand side of the stream, and it is 10.33 feet above the gage datum. As in previous years, the station was maintained through cooperation with the Denver Union Water Company. The observer is S. Hebrew, an employee of the Denver Union Water Company.

Observations at this station were discontinued in March, 1902, sufficient data having been secured since its establishment in 1888.

Daily gage height, in feet, of Bear Creek near Morrison, Colo.

Day.	Feb.	Day.	Feb.	Day.	Feb.	Day.	Feb.
1902.		1902.		1902.		1902.	
1	0.75	8	0.95	15	1.15	22	1.15
2	.75	9	.95	16	1.25	23	1.15
3	.80	10	1.05	17	1.20	24	1.25
4	.75	11	1.05	18	1.25	25	1.30
5	.85	12	1.05	19	1.35	26	1.35
6	.85	13	.95	20	1.25	27	1.45
7	.90	14	.92	21	1.20	28	1.45

SOUTH PLATTE RIVER AT SOUTH PLATTE, COLO.

This station is located at the junction of the North and South forks of the South Platte River at the town of South Platte, on the Colorado and Southern Railroad, about 9 miles above the mouth of the canyon. The station was established March 28, 1902, by John E. Field, at the wagon bridge crossing the main stream about 150 feet below the junction of the two forks. This station is of special importance, its location being above the diverting gates of all irrigating

ditches and also above the intake of the Denver Union Water Company, which derives the greater part of its supply of water from the South Platte River a few miles below this station. The location of the Cheesman Storage Reservoir on the South Fork, 20 miles above this station, and the contemplated installation of large power plants on the two forks above, also add to the importance of this station as a point from which to secure data. Bridges across either fork above the main station allow of measurements being made on these streams, thereby checking all gagings on the main stream below.

The gagings on the main stream are made at high water from a wooden wagon bridge 76 feet long, and at low water by wading. The channel at this point is composed of bowlders and gravel and is reasonably stable. The right bank is the mountain side, rising directly from the bed of the stream at a slope of about 45 degrees. The left bank is low and covered with trees, and liable to overflow at very high water. The gage rod consists of a 2 by 4 inch timber 7 feet long, spiked in a vertical position to the upstream face of the timber pier in the middle of the river; the bench mark, which is a nail driven into the cap timber of the pier just above the rod, is 10.15 feet above the zero of the rod. Observations have been made twice daily during the irrigating season since the establishment of the station. The observer during the summer of 1902 was John B. Sevan. This station is located only about 200 feet from the Colorado and Southern Railway station, and is easily accessible from Denver.

Discharge measurements of South Platte River at South Platte, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 28	J. E. Field	1.85	145
May 2	do	2.00	208
June 13	S. G. Lees	1.87	167
July 17	do	1.00	53
Do	do	1.04	60
August 12	do	1.00	53
August 25	J. E. Field	1.55	122
September 7	M. C. Hinderlider	1.20	69
September 8	J. E. Field	1.20	69
September 13	M. C. Hinderlider	1.25	79
September 23	do	1.45	108
October 17	S. G. Lees	1.20	60
October 27	R. W. Hawley	1.18	57

Daily gage height, in feet, of South Platte River at South Platte, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	1.72	1.11	2.50	1.55	1.00	1.20	1.20	0.95
2	1.72	1.56	2.15	1.50	1.00	1.20	1.30	.95
3	1.60	2.00	1.56	1.50	1.00	1.20	1.20	.97
4	1.55	1.55	1.56	1.50	.56	1.25	1.10	.97
5	1.55	1.55	1.56	1.40	1.25	1.20	1.10	.97
6	1.72	1.55	1.55	1.35	1.60	1.30	1.20	.85
7	1.82	1.55	1.56	1.30	1.30	1.30	1.10	.85
8	2.12	1.56	1.55	1.30	1.20	1.30	1.10	.90
9	3.30	1.11	1.56	1.30	1.10	1.40	1.10	.95
10	2.80	1.55	1.10	1.40	1.10	1.30	1.00	1.02
11	2.95	1.65	1.57	1.25	1.10	1.30	1.00	1.02
12	2.40	2.15	1.10	1.35	1.00	1.22	1.20	.....
13	2.80	2.15	1.50	1.35	1.05	1.25	1.20	.....
14	2.90	2.15	1.45	1.25	1.00	1.30	1.10	.....
15	2.85	2.15	1.50	1.15	1.15	1.30	1.10	.....
16	2.45	2.15	1.50	1.00	1.30	1.30	1.10	.....
17	2.25	2.15	1.45	1.35	1.40	1.20	1.10	.....
18	2.20	2.10	1.45	1.40	1.40	1.20	1.10	.....
19	2.20	2.05	1.45	1.40	1.40	1.20	1.00	.....
20	2.30	1.55	1.45	1.35	1.40	1.30	1.00	.....
21	2.30	1.10	1.80	1.25	1.40	1.40	1.00	.....
22	3.25	1.90	1.75	1.20	1.60	1.60	1.00	.....
23	2.00	1.85	1.60	1.25	1.60	1.35	.95	.....
24	1.90	1.80	1.60	1.20	1.20	1.25	.90	.....
25	1.90	1.75	1.55	1.20	1.20	1.15	.90	.....
26	1.90	1.45	1.50	1.20	1.40	1.10	1.02	.....
27	1.90	2.25	1.55	1.20	1.40	1.10	1.02	.....
28	1.90	2.40	1.50	1.15	1.40	1.15	.95	.....
29	1.82	2.65	1.85	1.15	1.35	1.20	.98	.....
30	1.90	2.55	1.65	1.10	1.20	1.20	1.02	.....
31	.....	2.45	.....	1.00	1.25	.....	1.02	.....

Rating table for South Platte River at South Platte, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	5	1.0	55	1.8	160	2.6	348
.3	8	1.1	65	1.9	178	2.7	380
.4	12	1.2	75	2.0	197	2.8	414
.5	18	1.3	86	2.1	218	2.9	449
.6	24	1.4	98	2.2	240	3.0	485
.7	30	1.5	112	2.3	264	3.1	521
.8	36	1.6	127	2.4	290	3.2	557
.9	45	1.7	143	2.5	318	3.3	593

Estimated monthly discharge of South Platte River at South Platte, Colo.

[Drainage area, 2,612 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	593	119	260	15,471	0.100	0.112
May	364	65	180	11,068	.069	.080
June	318	65	127	7,557	.049	.055
July	119	55	85	5,226	.033	.038
August	127	21	81	4,980	.031	.036
September	127	65	82	4,879	.031	.035
October	86	45	61	3,750	.023	.027
November 1–11			49	1,069	.019	.020

Miscellaneous measurements in Platte River drainage basin.

[Made by H. O. Smith, B. E. Forbes, J. C. Stevens, Frank Dobson, Adna Dobson, R. H. Willis.]

NEBRASKA.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
July 5	Buffalo Creek	Sec. 33, T. 9, R. 18	6.4
Do	do	Sec. 30, T. 10, R. 20	2.0
March 25	Calamus	Burwell	411
March 21	Elkhorn River, North Fork.	Norfolk	118
April 13	do	do	150
May 12	do	do	116
June 16	do	do	137
July 26	do	do	168
August 22	do	do	170
September 29	do	do	242
November 14	do	do	118
March 25	Loup, North	Burwell	1,088
March 23	do	St. Paul	1,186
Do	Loup, Middle	do	1,538
September 7	Platte River	Kearney	Dry.
August 26	Platte River, North	Sec. 3, T. 23, R. 58 W., State line.	31
August 28	do	do	31
September 8	do	do	8
September 22	do	do	630

Miscellaneous measurements in Platte River drainage basin—Continued.

NEBRASKA—Continued.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
April 9	Platte River, South	North Platte	Dry.
May 20	do	do	207
July 7	Salt Creek	Lincoln	[a]5,438
July 10	do	do	[a]10,136
October 1	do	do	92
August 18	Spring Creek	Sec. 30, T. 10, R. 21 W	1.0
April 23	do	Sec. 36, T. 14, R. 47 W	2.4
May 7	do	Sec. 30, T. 15, R. 37 W	2.5
September 7	Wood River	Sec. 12, T. 9, R. 16 W	27.3
July 17	Blue Creek	Sec. 6, T. 16, R. 42 W	90
August 18	do	Sec. 19, T. 16, R. 42 W	50
July 22	Lawrence Fork	Sec. 36, T. 19, R. 52 W	1.4
Do	do	Sec. 11, T. 18, R. 52 W	1.6
July 29	do	Sec. 1, T. 18, R. 52 W	2.9
July 31	do	Sec. 15, T. 18, R. 52 W	2.2
August 18	Lonergan Creek	Sec. 19, T. 15, R. 39 W	2.5
August 19	Sand Creek	Sec. 14, T. 15, R. 40 W	1.3
May 7	White Tail Creek	S. line sec. 36, T. 15, R. 38 W.	24.7
Do	do	N. line sec. 36, T. 15, R. 38 W.	36.0
Do	do	NE. ¼ sec. 26, T. 15, R. 38 W.	33.0
April 13	Lodge Pole	Sec. 36, T. 14, R. 47 W	4.0
April 25	do	Sec. 35, T. 15, R. 55 W	12.0
June 2	do	Kimball	5.6
July 2	do	Sec. 25, T. 15, R. 56 W	7.5
Do	do	Sec. 31, T. 15, R. 56 W	10.5

[a] Flood.

Miscellaneous measurements in the Platte drainage.

[Made by A. J. Parshall and W. P. Edwards.]

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-ft.*
September 11	North Platte River	Saratoga	108
September 12	do	At mouth of Brush Creek	63
September 14	do	Fort Steele	80
September 24	do	do	175
September 26	do	Big Bend	238
September 29	do	North of Seminole Mountains.	393
October 1	do	South of Seminole Mountains.	362
September 12	Brush Creek, Carbon County, Wyo.	At mouth	3.6
Do	Grand Encampment Creek, Carbon County, Wyo.	Near mouth	35
September 13	Cow Creek, Carbon County, Wyo.	do	.61
September 14	Pass Creek, Carbon County, Wyo.	do	.46
September 29	Medicine Bow River, Carbon County, Wyo.	do	40
January 1	South Fork, Crow Creek	Granite Canyon, Laramie County, Wyo.	1.23
January 8	Clear Creek (tributary Crow Creek).	Reis Springs, Laramie County, Wyo.	.10
Do	do	Corlett, Laramie County, Wyo.	.12
Do	North Fork, Clear Creek (tributary Crow Creek).	do	.14
January 15	Middle Crow	Simmons, Laramie County, Wyo.	3.75
March 12	do	At dam site, Laramie County, Wyo.	3.14
July 8	Bear Creek	Morrison	18
July 9	North Turkey Creek	Near Conifer	3
Do	Elk Creek	Winston	5
Do	Deer Park Creek	Bailey	4
Do	North Fork South Platte	do	70
July 10	Halls Gulch	Webster	14
Do	Jefferson Creek	Jefferson	16
Do	Michigan Creek	Como	6
Do	Tarryall Creek	Near Como	11
Do	Middle Fork South Platte River.	Fairplay	39
July 11	Fourmile Creek	Near Fairplay	4
Do	South Fork South Platte River.	Near Buffalo Springs	28

KANSAS RIVER DRAINAGE BASIN.

The drainage basin of the Kansas River lies between those of the Platte and Arkansas rivers, being entirely within the region of the Great Plains, and principally within the arid or semiarid area. It has no mountain tributaries, but depends entirely for its water supply upon the water which, falling within or near the basin, percolates slowly to the drainage channels. The catchment area extends from eastern Colorado to the Missouri River, a distance from east to west of 485 miles. Its extreme width is about 200 miles. The main stream of the Kansas River is formed at Junction, Kans., by the Republican and Smoky Hill rivers, and flows east into the Missouri at Kansas City. The Republican is its principal tributary and drains southern Nebraska and northern Kansas by means of many small tributary creeks. The Solomon, Saline, and Smoky Hill rivers drain the plains of northwestern Kansas. The Blue River is a small tributary in northeastern Kansas, flowing south into the Kansas River, near Manhattan, Kans. The following is a list of the stations in the Kansas River drainage basin:

Kansas River at Lecompton, Kans.
Blue River near Manhattan, Kans.
Republican River at Junction, Kans.
Republican River and the Mill Race near Superior, Nebr.
Solomon River at Niles, Kans.
Saline River near Salina, Kans.
Smoky Hill River at Ellsworth, Kans.

KANSAS RIVER AT LECOMPTON, KANS.

The gaging station at Lecompton was established April 16, 1899, at the new wagon bridge. On June 24, 1900, a new gage was established, the old gage having been broken. The present gage, a pine board 1 inch by 1 inch by 10 feet long, graduated to feet and tenths, is spiked on top of the old gage, and is at the same elevation. On October 26, 1900, a bench mark was established on top of the bottom flange of the iron strut connecting the two iron cylinders at the south end of the highway bridge over the river. The bench mark is at the west end of the strut, next to the cylinder. Its elevation is 12.19 feet above the zero of the gage. The observer is A. D. McAdow.

Discharge measurements of Kansas River at Lecompton, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 28	W. G. Russell	3.00	1,340
May 28	do	7.00	14,314
June 9	do	8.25	17,182
June 21	do	6.50	13,147
July 12	do	16.35	72,173
July 30	do	6.15	12,879
August 27	do	7.70	17,720

Daily gage height, in feet, of Kansas River at Lecompton, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.10	2.20	2.00	3.40	2.90	7.25	10.95	8.00	14.45	7.60	5.60	5.80
2	2.10	2.20	2.00	3.40	2.90	7.50	11.30	7.55	12.85	7.50	5.60	5.80
3	2.10	2.20	2.00	3.35	2.90	7.00	11.75	7.10	11.35	9.35	5.60	5.75
4	2.10	2.20	1.90	3.30	2.90	6.60	11.95	6.55	9.90	11.20	5.60	5.70
5	2.10	2.20	1.90	3.20	2.90	7.20	12.20	5.50	8.95	13.05	5.60	5.70
6	2.10	2.20	1.80	3.20	3.05	7.70	12.50	5.30	8.50	12.40	5.60	5.70
7	2.20	2.20	2.20	3.20	3.35	9.00	12.85	4.90	7.90	10.20	5.60	5.70
8	2.30	2.20	2.65	3.20	3.65	8.50	13.20	4.70	7.45	9.90	5.60	5.70
9	2.40	2.20	2.85	3.20	3.80	7.95	13.80	4.60	6.90	9.55	5.60	5.65
10	2.40	2.20	3.15	3.10	3.75	9.50	14.60	4.90	6.60	8.70	5.60	5.60
11	2.40	2.20	3.40	3.10	3.70	9.60	15.30	5.40	6.10	7.65	5.50	5.60
12	2.40	2.20	3.35	3.10	3.75	9.20	16.30	4.95	5.20	7.65	5.55	5.55
13	2.40	2.20	3.20	3.10	3.95	8.50	16.85	4.90	4.70	8.20	5.70	5.50
14	2.40	2.10	3.00	3.10	4.25	7.80	17.40	4.85	4.30	9.75	5.90	5.50
15	2.35	2.10	3.00	3.10	4.50	7.50	17.60	4.80	4.30	9.30	6.00	5.50
16	2.30	2.10	3.50	3.10	4.90	7.25	16.65	4.80	4.30	8.55	6.00	5.40
17	2.30	2.10	3.50	3.10	4.90	6.90	15.55	4.70	4.25	7.90	6.10	5.40
18	2.30	2.10	3.40	3.05	4.70	6.70	13.50	4.65	4.20	7.35	6.40	5.50
19	2.30	2.10	3.40	3.00	4.95	6.50	11.50	4.60	4.15	6.90	6.65	5.90
20	2.30	2.00	3.40	3.00	5.40	6.45	12.80	4.50	4.10	6.45	6.50	6.60
21	2.30	2.00	3.30	3.00	5.70	6.65	10.60	5.15	4.10	6.05	6.40	7.00
22	2.30	2.00	3.30	3.00	6.20	8.80	8.60	5.55	4.30	6.00	6.20	7.25
23	2.30	2.10	3.50	3.00	6.70	8.45	7.00	6.75	5.80	5.90	6.20	7.40
24	2.30	2.10	3.50	3.00	7.10	7.70	7.30	6.60	6.20	5.70	6.20	7.35
25	2.30	2.10	3.40	3.00	7.75	7.15	7.05	6.50	6.40	5.60	6.15	7.25
26	2.30	2.00	3.40	3.00	8.40	6.70	7.00	6.85	6.65	5.60	6.10	7.20
27	2.30	2.00	3.30	3.00	9.45	6.35	7.00	7.75	6.90	5.60	6.05	7.10
28	2.30	2.00	3.30	3.00	9.25	6.00	6.80	8.00	8.30	5.50	6.00	7.00
29	2.30	.....	3.30	5.00	7.60	9.00	6.35	8.20	8.80	5.40	6.00	7.00
30	2.30	.....	3.30	2.95	5.65	10.70	6.10	8.85	7.90	5.40	5.80	7.00
31	2.20	.....	3.30	.....	5.55	.....	7.15	12.85	.....	5.40	.....	6.90

Rating table for Kansas River at Lecompton, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	275	4.6	6,710	7.2	15,200	9.8	24,300
2.2	625	4.8	7,300	7.4	15,900	10.0	25,000
2.4	1,000	5.0	7,900	7.6	16,600	10.5	27,500
2.6	1,425	5.2	8,510	7.8	17,300	11.0	30,000
2.8	1,885	5.4	9,130	8.0	18,000	11.5	32,750
3.0	2,375	5.6	9,770	8.2	18,700	12.0	35,500
3.2	2,890	5.8	10,430	8.4	19,400	12.5	38,625
3.4	3,415	6.0	11,110	8.6	20,100	13.0	41,750
3.6	3,940	6.2	11,790	8.8	20,800	13.5	45,375
3.8	4,465	6.4	12,470	9.0	21,500	14.0	49,000
4.0	5,000	6.6	13,150	9.2	22,200	15.0	58,000
4.2	5,550	6.8	13,830	9.4	22,900	16.0	67,000
4.4	6,120	7.0	14,510	9.6	23,600	17.0	76,000

Estimated monthly discharge of Kansas River at Lecompton, Kans.

[Drainage area, 58,550 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	1,000	445	767	47,161	0.01	0.01
February	625	275	492	27,324	.01	.01
March	3,675	100	2,460	151,259	.04	.05
April	3,415	2,250	2,653	157,864	.05	.06
May	23,075	2,125	8,435	518,648	.14	.16
June	28,500	11,110	17,131	1,019,365	.29	.32
July	81,400	11,450	38,291	2,354,422	.65	.75
August	40,812	6,415	11,941	734,223	.20	.23
September	53,050	5,270	14,990	891,977	.26	.29
October	42,112	9,130	17,734	1,090,421	.30	.35
November	13,320	9,450	10,830	644,430	.18	.20
December	15,900	9,130	11,785	724,631	.20	.23
The year	81,400	100	11,459	8,361,725	.20	2.66

BLUE RIVER NEAR MANHATTAN, KANS.

The gaging station, established April 12, 1895, is at the county bridge 4 miles north of Manhattan. The gage rod consists of three sections, the lower being an ash stick driven into the bottom of the river and bolted to an overhanging cottonwood tree, 30 feet east of the

bridge. The other two sections of the rod are bolted to the south bridge pier. The bench mark is a cross cut in the capstone of the south bridge pier immediately above the upper gage, and is 32.135 feet above gage datum.

The observer is C. M. Matter.

Discharge measurements of Blue River near Manhattan, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 14	W. G. Russell	4.10	534
April 29	do	3.80	381
May 20	do	5.00	852
June 10	do	18.05	17,623
June 26	do	6.70	1,905
July 9	do	25.15	31,273
July 14[a]	do	26.85	31,060

[a] Backwater from Kansas River probably caused low discharge on July 14.

Daily gage height, in feet, of Blue River near Manhattan, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.20	(a)	a4.80	4.00	3.80	5.50	22.00	11.50	24.50	10.10	6.50	6.00
2	4.00	(a)	4.90	4.10	3.80	5.30	21.50	10.90	20.90	8.10	6.40	6.00
3	3.80	a3.80	5.00	4.10	3.80	5.20	19.30	10.00	17.90	7.60	9.90	5.90
4	3.80	(a)	4.70	4.10	4.80	5.10	18.70	9.40	13.10	13.10	8.80	6.20
5	3.90	a4.10	.....	4.20	4.10	5.00	18.60	8.80	9.40	15.60	7.30	6.20
6	4.00	(a)	.....	4.20	3.90	7.20	14.20	7.90	8.60	14.30	6.90	6.10
7	4.00	(a)	4.80	4.20	3.90	6.80	9.70	7.80	8.20	12.30	6.50	6.00
8	3.90	a4.20	4.60	4.20	3.90	13.00	19.40	7.60	7.90	11.30	6.40	5.80
9	3.90	(a)	4.60	4.20	3.90	16.00	25.00	7.50	7.40	9.70	6.30	5.80
10	3.80	(a)	4.50	4.10	3.90	18.50	29.00	7.30	7.10	9.00	6.20	5.70
11	4.00	a4.20	4.40	4.00	4.00	18.00	31.50	7.00	7.10	8.40	6.20	5.70
12	3.90	(a)	4.30	4.00	4.00	14.00	31.20	6.90	6.90	8.80	6.20	5.60
13	3.90	(a)	4.30	4.00	3.80	12.10	30.00	6.90	6.60	19.30	6.10	5.60
14	3.90	a4.30	4.10	4.00	4.80	11.60	28.50	6.80	6.50	16.20	6.70	5.50
15	3.90	(a)	4.10	4.00	4.60	13.70	18.70	6.70	6.50	12.30	7.60	5.40
16	3.90	a4.40	4.10	4.00	4.60	12.60	12.80	6.50	6.30	11.20	7.60	5.30
17	3.90	(a)	4.00	4.00	5.30	10.50	11.20	6.60	6.30	9.20	7.00	5.80
18	3.90	(a)	4.10	4.00	4.70	10.30	10.70	6.50	6.20	8.80	6.60	7.00
19	4.00	a4.40	4.20	4.00	5.30	10.60	11.20	6.50	6.10	8.30	6.50	6.00
20	4.00	(a)	4.20	4.00	5.20	13.50	14.80	7.90	6.10	8.00	6.40	8.20
21	4.00	(a)	4.20	3.90	4.90	15.50	13.20	8.20	6.00	7.80	6.40	7.70
22	4.00	a4.50	4.10	3.90	10.20	12.00	12.50	7.90	6.10	7.60	6.30	7.30
23	4.00	(a)	4.20	3.90	10.10	9.00	13.60	8.10	6.50	7.40	6.20	7.30
24	4.10	(a)	4.20	3.90	10.30	8.70	13.40	8.40	7.60	7.20	6.10	6.90
25	4.00	a4.70	4.10	3.90	18.00	7.50	14.80	8.20	10.70	7.10	6.10	6.70
26	a4.00	(a)	4.20	3.90	14.10	6.80	15.30	8.10	10.90	7.00	6.10	a7.00
27	a3.90	a5.00	4.10	3.90	8.80	6.40	11.30	10.40	10.60	6.90	6.20	a7.00
28	(a)	a4.80	4.00	3.80	7.80	13.50	11.50	11.20	9.10	6.80	6.20	a7.00
29	a3.90	.....	4.00	3.80	6.40	11.80	11.60	11.30	8.10	6.80	6.10	a7.00
30	(a)	.....	4.00	3.80	6.00	11.60	11.70	15.00	9.30	6.60	6.10	a7.00
31	a4.00	.....	4.00	.....	5.70	.....	11.80	23.30	.....	6.50	.....	a7.50

[a] Frozen.

Rating table for Blue River near Manhattan, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.0	140	6.8	2,006	10.6	5,468	15.0	11,760
3.2	204	7.0	2,150	10.8	5,684	15.5	12,710
3.4	268	7.2	2,306	11.0	5,900	16.0	13,670
3.6	336	7.4	2,462	11.2	6,124	16.5	14,630
3.8	408	7.6	2,624	11.4	6,348	17.0	15,590
4.0	480	7.8	2,792	11.6	6,576	17.5	16,550
4.2	560	8.0	2,960	11.8	6,808	18.0	17,510
4.4	640	8.2	3,136	12.0	7,040	18.5	18,470
4.6	726	8.4	3,312	12.2	7,280	19.0	19,430
4.8	818	8.6	3,492	12.4	7,520	19.5	20,390
5.0	910	8.8	3,676	12.6	7,764	20.0	21,350
5.2	1,014	9.0	3,860	12.8	8,012	21.0	23,270
5.4	1,118	9.2	4,052	13.0	8,260	22.0	25,190
5.6	1,228	9.4	4,244	13.2	8,560	23.0	27,110
5.8	1,344	9.6	4,440	13.4	8,860	24.0	29,030
6.0	1,460	9.8	4,640	13.6	9,186	25.0	30,950
6.2	1,592	10.0	4,840	13.8	9,538		
6.4	1,724	10.2	5,048	14.0	9,890		
6.6	1,862	10.4	5,256	14.5	10,820		

Estimated monthly discharge of Blue River near Manhattan, Kans.

[Drainage area, 9,490 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	560	408	461	28,346	0.05	0.06
February	910	408	619	34,378	.07	.07
March	910	480	618	37,983	.07	.08
April	560	408	483	28,740	.05	.06
May	17,510	408	2,157	132,629	.23	.27
June	17,510	910	6,298	374,757	.66	.74
July	43,430	4,540	16,866	1,037,050	1.78	2.05
August	27,686	1,790	4,329	266,180	.46	.53
September	29,990	1,460	5,011	298,175	.53	.59
October	20,006	1,790	5,071	311,804	.53	.61
November	4,740	1,526	1,945	115,735	.20	.22
December	3,136	1,066	1,897	116,642	.20	.23
The year	43,430	408	3,813	2,782,419	.40	5.51

REPUBLICAN RIVER AT JUNCTION, KANS.

The gaging station at this point, established by Arthur P. Davis, April 26, 1895, is located at the wagon bridge at the north end of Washington street just above the mouth of the river. The gage consists of two oak timbers bolted to a post and to a cottonwood tree. One bench mark consists of a 60-penny spike driven into the base of the abutment of the bridge at an elevation of 10.67 feet on the rod; the second bench mark is the top of a stone in the base of the bridge abutment 18 feet south of the gage and at an elevation of 14.51 feet above gage datum. The right bank is high, but the left is low and may overflow at high water. The bed of the stream is sandy and liable to change.

On October 23, 1900, a new bench mark was established, at an elevation of 12.35 feet above the zero of the old gage. It is a spike driven in the west side of a cottonwood tree 18 inches in diameter and 10 feet west of the bridge. The spike is about 2 feet above the ground. The observer is J. H. Rathert.

Discharge measurements of Republican River at Junction, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 13	W. G. Russell	4.00	846
April 29	do	3.65	556
May 19	do	5.10	2,047
June 5	do	4.80	1,777
June 16	do	5.10	2,180
June 25	do	4.80	1,740
July 7	do	7.55	7,713
July 8	do	10.25	16,601
July 15	do	6.65	5,308
September 27	do	8.50	10,207

Daily gage height, in feet, of Republican River at Junction, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.80	3.90	4.60	4.35	3.60	5.50	9.67	5.75	7.30	5.00	3.50	3.45
2	3.80	3.90	4.20	4.30	3.55	5.30	8.50	5.00	5.60	4.65	3.50	3.45
3	3.85	3.90	4.20	4.10	3.55	5.10	8.20	5.35	5.00	4.60	3.95	3.40
4	3.85	3.90	4.30	4.00	4.63	6.10	9.30	4.80	4.20	6.60	3.95	3.40
5	3.80	3.90	4.40	4.00	4.00	4.80	7.80	4.55	3.85	5.35	3.60	3.35
6	3.80	3.90	4.50	3.90	3.80	5.30	7.25	4.25	3.45	5.30	3.50	3.10
7	3.75	3.90	4.60	3.90	3.75	5.90	7.10	4.20	3.40	5.15	3.45	3.10
8	3.75	3.90	4.50	3.80	3.70	7.50	10.60	4.10	3.30	5.10	3.40	3.00
9	3.75	3.90	4.30	3.85	3.65	6.85	10.40	3.85	3.25	4.60	3.45	3.00
10	3.80	3.90	4.20	3.80	3.65	6.40	11.20	6.10	3.20	4.20	3.45	3.20
11	3.90	3.90	4.00	3.80	3.55	5.85	12.30	3.80	3.20	4.00	3.45	3.20
12	3.90	3.90	4.00	3.85	3.55	5.10	12.70	3.60	3.10	4.90	3.45	3.20
13	3.80	3.90	4.00	3.80	3.95	7.40	10.10	3.50	2.90	4.90	3.40	3.20
14	3.80	3.90	3.90	3.75	4.95	5.45	7.60	3.40	2.90	6.70	3.50	3.18
15	3.85	3.90	3.90	3.70	4.70	6.20	6.60	4.50	2.90	4.90	3.65	3.08
16	3.90	3.90	3.85	3.72	4.00	5.20	6.20	3.35	2.85	4.80	3.70	3.12
17	3.90	3.90	3.85	3.72	4.40	4.80	5.75	3.25	2.65	4.40	3.60	3.25
18	3.90	3.90	3.80	3.70	4.20	5.50	5.40	3.10	2.80	4.20	3.60	3.30
19	3.90	3.90	3.80	3.70	4.50	5.40	5.00	3.50	2.75	4.00	3.50	3.30
20	3.90	3.90	3.75	3.60	5.40	5.60	4.80	3.60	2.75	3.85	3.50	3.35
21	4.00	3.90	3.70	3.60	6.10	6.20	4.70	7.60	2.70	3.90	3.50	3.65
22	4.00	3.90	3.90	3.70	6.40	5.30	5.30	4.70	2.70	3.85	3.45	3.38
23	4.10	3.90	3.90	3.65	6.55	5.00	4.75	3.90	3.35	3.80	3.40	3.35
24	4.00	3.90	3.85	3.60	6.60	4.90	4.40	3.90	3.65	3.75	3.50	3.30
25	3.90	4.00	3.80	3.60	6.65	4.80	4.20	3.80	5.10	3.65	3.50	3.28
26	3.90	4.00	3.90	3.65	7.60	4.60	4.20	3.50	8.20	3.60	3.40	3.28
27	3.90	4.10	3.90	3.65	6.70	4.40	4.00	5.85	8.50	3.55	3.40	3.30
28	3.90	4.55	3.85	3.65	5.60	5.23	4.20	5.10	5.90	3.55	3.45	3.65
29	3.90	.....	3.85	3.62	5.70	7.60	8.20	6.65	5.70	3.50	3.45	3.42
30	3.90	.....	3.90	3.65	5.60	7.80	8.40	6.95	5.50	3.50	3.40	3.55
31	3.90	.....	4.10	.....	5.90	.....	7.50	8.90	.....	3.45	.....	3.48

Rating table for Republican River at Junction, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	20	4.6	1,480	7.0	6,000	9.4	13,200
2.4	30	4.8	1,720	7.2	6,600	9.6	13,800
2.6	70	5.0	1,960	7.4	7,200	9.8	14,400
2.8	140	5.2	2,210	7.6	7,800	10.0	15,000
3.0	220	5.4	2,520	7.8	8,400	10.2	15,600
3.2	300	5.6	2,840	8.0	9,000	10.4	16,200
3.4	400	5.8	3,200	8.2	9,600	10.6	16,800
3.6	510	6.0	3,600	8.4	10,200	10.8	17,400
3.8	630	6.2	4,000	8.6	10,800	11.0	18,000
4.0	840	6.4	4,400	8.8	11,400	11.5	19,500
4.2	1,050	6.6	4,900	9.0	12,000	12.0	21,000
4.4	1,260	6.8	5,400	9.2	12,600	13.0	24,000

Estimated monthly discharge of Republican River at Junction, Kans.

[Drainage area 25,837 square miles.]

Month.	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
January	945	600	710	43,656	0.03	0.03
February	1,425	735	775	43,041	.03	.03
March	1,480	570	887	54,539	.03	.03
April	1,207	510	654	38,916	.03	.03
May	7,800	482	2,128	130,846	.08	.09
June	8,400	1,260	3,338	198,625	.13	.15
July	23,100	840	7,887	484,953	.30	.35
August	11,700	260	2,046	125,804	.08	.09
September	10,500	88	1,646	97,944	.06	.07
October	5,150	427	1,436	88,296	.06	.07
November	787	400	471	28,026	.02	.02
December	2,443	220	422	25,944	.02	.02
The year	23,100	88	1,867	1,360,590	.07	.98

REPUBLICAN RIVER AND THE MILL RACE NEAR SUPERIOR, NEBR.

This station was established June 20, 1896, about one mile west of Superior, Nebr. The old gage rod was first placed just above the highway bridge, which is itself 75 yards above the dam which diverts water into the mill race.

This gage consists of an oak piece 2 by 4 inches, 10 feet long. The face is inclined 30 degrees to the horizontal, and the footmarks are placed 2 feet apart to correspond to this inclination. The rod is fastened to cross-ties which are bedded in the bank of the river. The location is on the outside of an easy bend in the river. The bed of the river is of mud and sand. The top of the rim of the upstream cylinder of the north pier is 15.42 feet above the zero of the gage. Bench mark 2 is the standard 4-foot iron pipe of the United States Geological Survey. It is 83 feet north of the upstream cylinder of the north pier of the bridge and is 10 feet west of the line of the upstream truss of the bridge. It is 1 foot inside a wire fence. The top of the pipe is 4 inches above the ground and the elevation is 4.88 feet above gage datum.

In the spring of 1898 two other gages were established. The first gage was placed in the river a few feet upstream from the crest of the dam, the zero being at the same elevation as the crest. The second is

in the mill race, which is crossed by a wagon bridge about 50 yards below its head. Discharge measurements of the river are made from the highway bridge, thus determining at once the discharge through the mill race and from the dam. The discharge from the mill race is measured and is deducted from the total discharge of the river to give the amount passing over the dam. The bench mark for this river gage is bench mark No. 2 of the old gage described above. Its elevation is 4.92 feet above the datum of the gage at the dam. The gage of the mill race reads 2 feet higher than that of the river gage, so that its zero is 6.92 feet below the same bench mark.

It was found, however, that the discharge of the mill race was regulated more or less by the mill below, so that there was no relation whatever between the gage height and the discharge. To remedy this difficulty the observer records the depth of water in midstream at the wagon bridge and immediately thereafter notes number of seconds required for a float to pass over a 50-foot range in midstream. The ratios of the time to the depth was found to bear a constant relation to the discharge.

During 1899 Glenn E. Smith made an examination of a portion of the upper Republican River. On September 6, 1899, at Oxford, Nebr., the river channel was dry and was reported to have been in this condition for ten days. At Orleans, about 12 miles below, there was an estimated discharge of 0.3 second-foot—this small amount coming from Sappa River, which enters at this point.

Discharge measurements of Republican River near Superior, Nebr.[a]

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 16	Frank Dobson	0.75	625
April 5	J. C. Stevens	.70	638
May 24	Frank Dobson	1.30	1,499
July 8	J. C. Stevens	([b])	12,494
July 30	do	1.25	1,562
August 12	do	.73	553
September 19	do	.39	154

[a] These discharges include that flowing in the mill race.
[b] Water out of banks on both sides and over top of gage rod.

Discharge measurements of mill race near Superior, Nebr.[a]

Date.	Hydrographer	Discharge.	Date.	Hydrographer.	Discharge.
1902.		*Sec.-feet.*	1902.		*Sec.-feet.*
March 16	Frank Dobson	22	July 30	J. C. Stevens	119
April 5	J. C. Stevens	54	August 12	do	54
May 24	Frank Dobson	35	September 19	do	3

[a] Gage heights are not observed, but depth of water in midstream and the time required for a float to pass over a 50-foot range in midstream, the ratios of which are used instead of gage heights.

Daily gage height, in feet, of Republican River near Superior, Nebr.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	.....	0.80	0.56	1.10	1.98	1.42	0.70	1.00	0.60
2	.....	.80	.50	1.00	2.32	1.20	.68	.98	.60
3	.....	.71	.70	1.05	2.05	1.05	.65	1.05	.59
4	.....	.73	.46	1.32	1.30	1.18	.61	1.19	.55
5	.....	.70	.49	.95	2.40	.95	.60	1.35	.56
6	.....	.70	.53	1.95	(b)	.92	.58	1.00	.63
7	.....	.62	.90	1.90	(b)	.90	.52	.98	.60
8	(a)	.56	1.02	1.92	(b)	.82	.53	.90	.61
9	0.90	.55	1.15	1.48	(b)	.80	.45	.89	.62
10	.85	.58	.85	1.30	3.50	.70	.42	.82	.70
11	.80	.68	.75	1.42	2.55	.81	.48	.88	.71
12	.80	.78	.69	1.00	1.88	.70	.40	1.05	.73
13	.80	.68	.86	.95	1.92	.62	.32	1.45	.74
14	.83	.60	.80	.88	1.72	.80	.31	1.00	.78
15	.75	.60	.78	1.05	1.42	.78	.40	.85	.71
16	.75	.62	.70	.82	1.30	.65	.41	.82	.78
17	.70	.68	.70	.70	1.15	.60	.32	.99	.74
18	.85	.65	.75	.85	1.68	.55	.48	.90	.79
19	.80	.62	1.85	1.38	1.80	.52	.34	.91	.75
20	.64	.70	1.69	1.20	1.10	.51	.35	.83	.74
21	.60	.65	1.53	1.20	1.05	.50	.40	.78	.71
22	.75	.63	1.42	1.08	1.00	.52	1.85	.70	.71
23	.78	.67	1.20	.95	.92	.68	3.60	.71	.67
24	.75	.65	1.30	.90	1.02	.50	2.32	.72	.80
25	.68	.62	1.56	.82	1.08	.50	1.86	.70	.80
26	.80	.58	1.95	.76	(b)	.50	1.78	.73	.70
27	.81	.60	1.95	.68	3.25	.60	1.35	.75	.90
28	.97	.56	1.65	.65	3.00	.58	1.10	.75	.70
29	.52	.56	1.75	.78	1.60	.59	1.05	.72	.80
30	.83	.52	1.25	1.10	1.20	.67	1.02	.71	(a)
31	.81	.....	1.20	.....	1.70	.62	.....	.72	.....

[a] Observations discontinued from Jan. 1 to Mar. 9 and during December on account of ice.
[b] Flood; water over top of gage.

Rating table for Republican River near Superior, Nebr., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	45	1.0	850	1.9	2,780	2.8	6,155
.2	95	1.1	1,010	2.0	3,075	2.9	6,630
.3	150	1.2	1,190	2.1	3,390	3.0	7,125
.4	215	1.3	1,390	2.2	3,725	3.1	7,650
.5	285	1.4	1,610	2.3	4,080	3.2	8,195
.6	360	1.5	1,840	2.4	4,455	3.3	8,760
.7	460	1.6	2,085	2.5	4,850	3.4	9,345
.8	570	1.7	2,340	2.6	5,265	3.5	9,950
.9	690	1.8	2,505	2.7	5,700	3.6	10,575

[a] This table was applied indirectly according to the method outlined on page 323, Nineteenth Annual Report United States Geological Survey, Part IV, and gives the discharge over the dam, exclusive of that flowing in the mill race.

Estimated monthly discharge of Republican River near Superior, Nebr.

[Drainage area, 22,347 square miles.]

Month.	Discharge in second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
March 9 to 31			675	29,453	0.03	0.02
April	740	390	555	33,020	.02	.02
May	2,810	335	1,269	78,020	.06	.07
June	3,235	320	1,372	81,640	.06	.07
July	12,490	970	[a] 3,080	[a] 189,360	[a] .14	[a] .16
August	1,920	330	674	41,440	.03	.03
September	10,875	155	1,175	69,910	.05	.06
October	1,995	520	937	57,610	.04	.05
November	970	460	622	37,010	.03	.03

[a] Exclusive of four days' flood discharge.

SOLOMON RIVER AT NILES, KANS.

The station at Niles was established May 5, 1897, and is located at a bridge one-half mile west of the town and 7 miles above the mouth of the river. The rod of the wire gage is spiked to the floor of the bridge. The bench mark is the uppermost of three nails driven into a cottonwood tree 18 inches in diameter, on the north side of the river and 25 feet east of the bridge, at an elevation of 24.96 feet above gage

datum. The channel is straight for about 100 feet above and below the section. The current is sluggish; the right bank is high, and the left bank overflows only at very high stages. The bed of the stream is muddy.

The observer is J. J. Little.

Discharge measurements of Solomon River at Niles, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 30	W. G. Russell	4.50	72
June 5	do	7.20	409
June 26	do	7.80	555
July 3	do	27.30	6,561
October 1	do	29.10	8,623

Daily gage height, in feet, of Solomon River at Niles, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	.....	(a)	(a)	4.60	4.60	9.10	26.10	14.50	8.40	29.10	8.70	7.40
2	.....	(a)	5.10	5.50	4.80	7.70	27.60	10.00	9.00	28.50	8.60	7.40
3	.....	a 5.00	5.00	5.30	4.70	6.60	27.30	10.00	9.70	14.70	8.80	7.30
4	a 4.90	(a)	4.20	5.20	4.70	10.70	25.80	7.90	9.10	13.50	9.10	7.30
5	(a)	a 5.30	4.30	5.10	4.60	7.60	21.70	7.70	7.50	13.90	8.60	7.20
6	a 5.00	(a)	4.20	4.90	4.50	7.10	17.60	7.30	6.80	16.90	8.40	7.20
7	(a)	(a)	5.70	4.80	4.60	9.80	13.40	7.00	6.40	17.30	8.30	7.20
8	(a)	a 5.10	5.90	4.70	4.50	16.00	14.30	6.70	6.80	18.10	8.20	7.20
9	(a)	(a)	5.70	4.60	4.50	14.50	17.10	6.70	6.80	16.00	8.20	6.90
10	a 5.00	a 5.00	5.30	4.70	4.50	11.00	21.30	14.50	6.20	14.20	8.10	7.00
11	(a)	(a)	5.30	4.90	4.60	10.40	22.10	14.00	5.80	12.30	8.10	6.60
12	(a)	a 5.10	5.20	4.90	4.70	9.40	21.40	11.70	5.50	11.30	8.10	7.20
13	a 4.90	(a)	5.20	4.80	4.80	8.20	20.30	9.50	5.50	14.30	8.10	7.00
14	(a)	(a)	5.00	4.70	4.60	12.40	10.80	10.30	5.60	17.30	8.10	7.00
15	a 5.00	a 5.20	4.90	4.90	4.60	7.80	9.20	10.70	5.60	16.80	8.10	6.70
16	(a)	(a)	4.80	4.90	4.70	7.40	8.80	8.70	5.50	16.40	8.10	6.90
17	a 4.90	(a)	4.80	4.70	4.60	8.80	8.00	7.70	5.60	14.40	7.80	7.50
18	(a)	a 5.40	5.00	4.80	4.60	11.00	7.50	7.30	5.60	12.20	7.80	6.70
19	a 5.20	(a)	4.70	4.90	4.20	12.40	7.30	7.00	5.40	14.40	7.80	7.10
20	(a)	a 5.00	4.70	4.90	4.70	8.70	7.00	6.50	5.30	10.50	7.80	7.40
21	(a)	(a)	4.70	4.60	4.60	12.50	6.80	7.70	5.30	10.30	7.70	7.10
22	a 5.50	a 5.10	4.80	4.70	5.60	14.60	6.90	8.60	5.40	10.00	7.70	6.90
23	(a)	(a)	5.00	4.80	5.80	12.10	6.70	8.00	5.30	9.80	7.60	6.90
24	a 5.00	a 5.30	4.90	4.70	7.80	11.30	6.30	7.70	11.30	9.60	7.50	6.90
25	(a)	(a)	4.90	4.80	7.60	9.50	6.60	8.60	18.20	9.60	7.50	6.60
26	a 5.20	a 5.40	5.00	4.80	7.10	8.40	6.50	7.90	22.00	9.30	7.50	7.10
27	(a)	(a)	4.90	4.80	11.30	7.10	6.30	8.10	22.70	9.30	7.40	7.10
28	a 5.00	a 5.20	4.80	4.80	11.00	7.00	6.20	10.10	24.90	9.30	7.40	7.10
29	(a)	.....	5.00	4.40	9.10	20.00	6.60	8.40	25.60	9.10	7.40	6.90
30	(a)	.....	4.70	4.60	10.60	25.30	17.90	7.20	27.60	8.80	7.40	6.90
31	a 5.00	.....	4.80	.....	8.40	.....	20.20	8.20	.....	8.70	.....	7.10

a Frozen.

Rating table for Solomon River at Niles, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.0	22	7.4	470	10.8	1,285	14.5	2,375
4.2	38	7.6	512	11.0	1,337	15.0	2,550
4.4	54	7.8	556	11.2	1,389	16.0	2,900
4.6	70	8.0	600	11.4	1,441	17.0	3,250
4.8	86	8.2	646	11.6	1,493	18.0	3,600
5.0	102	8.4	692	11.8	1,547	19.0	3,950
5.2	122	8.6	738	12.0	1,604	20.0	4,300
5.4	142	8.8	784	12.2	1,663	21.0	4,650
5.6	162	9.0	830	12.4	1,722	22.0	5,000
5.8	192	9.2	880	12.6	1,782	23.0	5,350
6.0	222	9.4	930	12.8	1,841	24.0	5,700
6.2	252	9.6	980	13.0	1,900	25.0	6,050
6.4	282	9.8	1,030	13.2	1,960	26.0	6,400
6.6	316	10.0	1,080	13.4	2,020	27.0	6,800
6.8	352	10.2	1,130	13.6	2,080	28.0	7,220
7.0	390	10.4	1,181	13.8	2,140	29.0	7,730
7.2	430	10.6	1,233	14.0	2,200	30.0	8,300

Estimated monthly discharge of Solomon River at Niles, Kans.

[Drainage area, 6,815 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	152	94	106	6,517	0.02	0.02
February	142	102	119	6,608	.02	.02
March	207	38	101	6,210	.02	.02
April	152	54	89	5,296	.01	.01
May	1,415	38	285	17,524	.04	.05
June	6,155	316	1,392	82,830	.20	.22
July	7,040	252	2,492	153,227	.37	.43
August	2,375	299	847	52,080	.12	.14
September	7,040	132	1,392	82,830	.20	22
October	7,780	761	2,263	139,145	.33	38
November	855	470	601	35,764	.09	.10
December	490	316	402	24,718	.06	.07
The year	7,780	38	841	612,749	.12	1.68

SALINE RIVER NEAR SALINA, KANS.

The station, established May 4, 1897, is located at a bridge 4.5 miles northeast of Salina, near the mouth of the river. The rod of the wire gage is spiked to the floor of the bridge. Bench mark No. 1 is a nail in an elm tree 2 feet in diameter on the north side of the river and 6 feet west of the bridge. Its elevation is 22.90 feet above gage datum. Bench mark No. 2 is six nails driven into a 16-inch box-elder tree on the north side of the river and 35 east of the bridge. Its elevation is 22.90 feet above gage datum. The channel is straight for a short distance above and below the station. Both banks are high and not liable to overflow. The bed of the stream is sand and mud. The observer is Charley Tressin.

Discharge measurements of Saline River near Salina, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 6	W. G. Russell	4.00	22
April 30	do	3.30	23
May 11	do	3.20	24
June 2	do	4.70	116
June 11	do	6.80	326
July 2	do	17.40	2,017
July 23	do	4.80	131
September 30	do	24.50	3,822
October 2	do	21.10	2,664
November 29	do	6.10	231

Daily gage height, in feet, of Saline River near Salina, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.70	(a)	4.10	3.60	3.40	5.70	15.80	6.10	9.00	24.50	7.20	6.10
2	3.70	a 4.10	4.30	3.50	3.40	4.60	18.20	5.50	13.50	20.90	7.20	6.10
3	3.80	(a)	4.30	3.60	3.30	4.20	20.20	5.20	12.00	10.80	7.70	6.10
4	3.90	a 4.00	3.80	3.50	3.20	4.30	20.30	5.00	8.60	15.30	7.60	6.00
5	4.20	(a)	3.80	3.50	3.40	9.10	10.50	5.00	7.50	15.70	7.20	6.10
6	4.00	a 4.00	3.60	3.40	3.40	12.00	8.90	4.80	6.60	15.00	7.00	6.00
7	4.00	(a)	3.70	3.60	3.30	15.80	7.90	4.70	6.20	16.10	6.90	5.70
8	4.10	a 4.10	3.90	3.40	3.30	16.90	14.50	4.60	5.90	16.90	6.70	5.50
9	4.10	a 4.10	3.90	3.40	3.40	13.90	9.50	5.70	5.70	15.00	6.80	5.80
10	4.20	(a)	3.70	3.50	3.30	8.40	16.10	5.20	5.50	11.60	6.70	5.70
11	4.00	a 4.20	3.60	3.40	3.20	6.80	10.80	7.20	5.30	10.70	6.70	5.50
12	4.00	(a)	3.90	3.40	3.10	8.20	7.40	9.50	5.20	10.00	6.60	5.80
13	4.10	a 4.10	3.60	3.50	3.30	7.30	6.60	12.00	5.00	9.60	6.70	5.95
14	4.20	(a)	3.60	3.50	3.10	7.20	6.60	7.40	5.00	10.70	6.70	6.35

a Frozen.

Daily gage height, in feet, of Saline River near Salina, Kans.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
15	4.00	a 4.10	3.60	3.40	3.10	12.10	6.00	6.20	4.90	15.20	6.60	6.25
16	4.20	a 4.20	3.60	3.40	3.20	12.50	5.70	5.50	4.90	17.10	6.60	6.20
17	4.20	(a)	3.70	3.50	3.20	13.50	5.40	5.00	4.90	16.00	6.60	6.30
18	4.20	a 4.20	3.60	3.40	3.10	14.40	5.30	4.70	4.80	10.80	6.40	6.20
19	4.30	(a)	3.40	3.40	3.10	11.00	5.10	5.20	4.80	9.60	6.40	5.90
20	4.50	(a)	3.60	3.30	3.20	8.40	5.10	5.10	4.80	9.10	6.40	5.60
21	4.00	a 3.90	3.50	3.40	3.50	14.90	4.80	5.30	4.70	8.70	6.30	5.80
22	4.00	a 3.60	3.40	3.50	4.00	14.50	4.90	6.20	5.00	8.40	6.30	5.90
23	4.00	3.80	3.50	3.40	4.00	12.70	4.80	10.00	12.00	8.20	6.30	6.05
24	4.00	3.60	3.50	3.30	3.50	7.90	4.80	14.40	17.80	8.10	6.30	5.95
25	4.10	3.60	3.60	3.30	7.20	7.50	4.70	14.00	17.50	7.90	6.20	5.90
26	a 4.20	3.80	3.60	3.50	7.50	6.80	4.90	15.40	18.00	7.80	6.30	6.10
27	(a)	3.90	3.60	3.40	6.70	6.30	4.80	16.70	19.60	7.70	6.20	6.35
28	a 4.30	3.80	3.60	3.20	7.00	6.30	4.90	17.00	21.40	7.50	6.20	5.85
29	(a)	.....	3.60	3.30	9.70	13.10	4.70	10.00	23.40	7.40	6.10	5.70
30	a 4.00	.....	3.60	3.10	7.20	13.70	7.50	7.50	24.50	7.30	6.10	5.60
31	a 4.10	.....	3.60	.....	5.80	.....	6.40	6.90	.....	7.20	.....	5.65

a Frozen.

Rating table for Saline River near Salina, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.2	28	6.8	320	10.4	796	14.0	1,370
3.4	34	7.0	340	10.6	824	14.5	1,460
3.6	41	7.2	364	10.8	852	15.0	1,550
3.8	50	7.4	388	11.0	880	15.5	1,640
4.0	60	7.6	412	11.2	910	16.0	1,730
4.2	70	7.8	436	11.4	940	16.5	1,820
4.4	80	8.0	460	11.6	970	17.0	1,910
4.6	100	8.2	488	11.8	1,000	17.5	2,000
4.8	120	8.4	516	12.0	1,030	18.0	2,090
5.0	140	8.6	544	12.2	1,064	18.5	2,180
5.2	160	8.8	572	12.4	1,098	19.0	2,270
5.4	180	9.0	600	12.6	1,132	19.5	2,360
5.6	200	9.2	628	12.8	1,166	20.0	2,450
5.8	220	9.4	656	13.0	1,200	20.5	2,545
6.0	240	9.6	684	13.2	1,234	21.0	2,640
6.2	260	9.8	712	13.4	1,268	22.0	2,860
6.4	280	10.0	740	13.6	1,302	23.0	3,170
6.6	300	10.2	768	13.8	1,336	24.0	3,620

Estimated monthly discharge of Saline River near Salina, Kans.

(Drainage area, 3,311 square miles.)

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	90	45	64	3,935	0.019	0.022
February	70	41	60	3,332	.018	.019
March	75	34	45	2,767	.014	.016
April	41	25	35	2,083	.011	.012
May	698	25	112	6,886	.034	.039
June	1,892	70	792	47,127	.239	.267
July	2,507	110	621	38,184	.188	.217
August	1,910	100	512	31,482	.155	.179
September	3,920	110	874	52,007	.264	.295
October	3,920	364	1,089	66,960	.329	.379
November	424	250	305	18,159	.092	.103
December	275	190	234	14,388	.071	.082
The year	3,920	25	395	287,310	.120	1.630

SMOKY HILL RIVER AT ELLSWORTH, KANS.

The gaging station, established April 17, 1895, is located at the highway bridge on Douglass avenue, Ellsworth, Kans. The gage is an inclined ash timber spiked to a post driven in the bed of the river and bolted to an iron post on the bridge pier. The bench mark is a nail driven into the base of a large box-elder tree near the southeast corner of the bridge, 90 feet from the gage, and its elevation is 13.07 feet above the zero of the gage. A slope gage is spiked to the St. Louis and San Francisco Railroad bridge 2,536 feet upstream, and is referred to the same datum. The channel is nearly straight above and below the gage, and the bed is sandy and shifting. The observer is Thomas Coyne.

Discharge measurements of Smoky Hill River at Ellsworth, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 27	W. G. Russell	1.00	20
June 23	do	6.20	2,830
June 24	do	4.50	1,530
August 18	do	1.40	96
August 28	do	3.50	651

Daily gage height, in feet, of Smoky Hill River at Ellsworth, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	[a] 1.20	[a] 0.80	1.50	0.95	0.75	1.30	5.20	2.90	3.00	3.60	1.80	1.25
2	[a] 1.20	[a] .80	1.40	.95	.75	1.20	4.60	2.75	2.80	3.40	1.85	1.25
3	[a] 1.20	[a] .80	1.30	.90	.75	1.20	4.30	2.60	2.70	3.60	1.85	1.20
4	[a] 1.20	[a] .80	1.20	.90	.75	2.20	3.90	2.50	2.60	4.10	1.80	1.20
5	[a] .90	[a] .80	1.10	.90	.75	1.70	3.40	2.30	2.40	4.20	1.80	1.20
6	[a] .90	[a] .80	1.10	.90	.75	1.50	3.00	2.10	2.30	4.00	1.75	1.20
7	[a] .90	[a] .80	1.00	.90	.70	1.30	2.80	2.00	2.20	3.80	1.70	1.20
8	[a] .90	[a] .80	1.00	.85	.70	1.25	3.80	2.25	2.00	3.50	1.60	1.15
9	[a] .90	[a] .85	1.00	.85	.70	1.20	3.40	2.20	1.90	3.30	1.60	1.15
10	[a] .90	[a] .85	.95	.85	.70	1.20	3.00	1.95	1.85	3.10	1.55	1.15
11	[a] .90	[a] .85	.95	.85	.70	1.15	6.70	1.80	1.80	2.90	1.50	1.15
12	[a] .90	[a] .90	.95	.80	.70	1.10	5.60	1.80	1.70	2.70	1.60	1.10
13	[a] .90	[a] .90	.90	.80	.70	3.00	5.00	1.75	1.70	2.50	1.65	1.10
14	[a] .90	[a] .90	.90	.80	.85	2.00	4.50	2.20	1.65	2.80	1.70	1.10
15	[a] .85	[a] .90	.90	.80	.80	1.70	3.50	2.00	1.60	3.00	1.65	1.20
16	[a] .85	[a] .95	.90	.80	.80	2.50	2.70	1.80	1.60	2.60	1.65	1.20
17	[a] .85	[a] .95	.85	.80	.75	2.30	2.50	1.60	1.55	2.60	1.65	1.20
18	[a] .85	[a] 1.10	.85	.80	.80	2.10	2.20	1.40	1.50	2.50	1.60	1.20
19	.85	[a] 1.20	.85	.80	.85	2.10	2.00	1.30	1.50	2.35	1.60	1.30
20	.85	[a] 1.20	.85	.75	.85	8.75	1.90	1.25	1.50	2.30	1.60	1.40
21	.85	[a] 1.30	.90	.75	1.60	5.50	1.80	3.80	1.50	2.20	1.55	1.40
22	.80	[a] 1.50	.90	.85	2.20	4.90	1.80	6.50	1.65	2.20	1.55	1.30
23	.80	1.10	.90	.85	2.20	6.00	1.70	8.30	3.00	2.15	1.50	([a])
24	.80	1.20	.95	.85	2.00	4.50	1.65	12.00	12.60	2.10	1.50	([a])
25	[a] .80	1.20	.95	.80	1.80	3.80	3.00	6.50	9.00	2.00	1.45	1.40
26	[a] .80	1.30	2.15	.80	3.05	3.50	2.60	5.00	7.80	2.00	1.40	([a])
27	[a] .80	1.50	1.00	.80	1.70	3.20	2.40	4.20	6.20	2.00	1.35	([a])
28	[a] .80	1.50	1.00	.80	1.50	3.00	2.20	3.50	5.20	1.95	1.30	([a])
29	[a] .80	.....	.95	.80	1.50	5.40	2.00	3.30	4.60	1.90	1.25	([a])
30	[a] .80	.....	.95	.80	1.50	5.00	3.40	3.10	3.90	1.85	1.25	([a])
31	[a] .80	.....	.95	.....	1.45	.....	3.20	3.80	.....	1.85	.....	([a])

[a] River frozen.

Rating table for Smoky Hill River at Ellsworth, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	9	2.6	485	4.6	1,670	6.6	3,190
0.8	17	2.8	575	4.8	1,810	6.8	3,345
1.0	25	3.0	675	5.0	1,950	7.0	3,500
1.2	55	3.2	780	5.2	2,105	8.0	4,275
1.4	85	3.4	900	5.4	2,260	9.0	5,050
1.6	125	3.6	1,020	5.6	2,415	10.0	5,825
1.8	175	3.8	1,140	5.8	2,570	11.0	6,600
2.0	235	4.0	1,260	6.0	2,725	12.0	7,375
2.2	310	4.2	1,390	6.2	2,880		
2.4	395	4.4	1,530	6.4	3,035		

Estimated monthly discharge of Smoky Hill River at Ellsworth, Kans.

[Drainage area, 7,980 square miles.]

Month.	Discharge in second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
January	55	17	24	1,475	0.003	0.003
February	100	17	38	2,110	.005	.005
March	290	19	39	2,398	.005	.006
April	23	15	18	1,071	.002	.002
May	700	13	87	5,349	.011	.013
June	4,856	40	821	48,853	.103	.115
July	3,267	137	891	54,785	.112	.129
August	7,375	62	1,021	62,779	.128	.148
September	7,840	100	1,033	61,468	.130	.144
October	1,390	187	588	36,155	.074	.085
November	187	62	125	7,438	.016	.017
December	85	40	64	3,935	.008	.009
The year	7,840	13	396	287,816	.050	.676

Miscellaneous measurements in Kansas River drainage basin in Nebraska.

[Made by J. C. Stevens, B. E. Forbes, H. O. Smith, Frank Dobson.]

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
April 5	Blue River	Seward	50
April 18	do	Crete	143
Do	do	do	132
September 16	do	Wymore	234
July 2	Crooked Creek	Sec. 1, T. 1, R. 11 W	[a] 175
June 10	Center Creek	Sec. 36, T. 2, R. 15 W	7.6
Do	do	Sec. 7, T. 1, R. 15 W	7.7
April 25	Frenchman River	Culbertson	92
June 13	do	Enders	60
September 18	do	Culbertson	66
June 10	Lost Creek	Sec. 10, T. 1, R. 15 W	0.7
April 25	Republican	Culbertson	204
April 26	do	Ives	39
Do	do	Stratton	85
Do	do	Haigler	52
April 27	do	Oxford	255

Miscellaneous measurements in Kansas River drainage basin in Nebraska—Continued.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
April 27	Republican	McCook	137
June 10	do	Franklin	743
June 12	do	Benkleman	35
September 17	do	Oxford	37
Do	do	McCook	29
Do	do	Benkleman	45
September 18	do	Culbertson	41
June 12	Republican, South Fork	State Line	32.8
September 17	do	Benkleman	31.6
April 26	Rock Creek	Ives	9.9

[a] Flood.

ARKANSAS RIVER DRAINAGE BASIN.

The Arkansas River rises in the central part of Colorado, flows south for about 70 miles, then east for 50 miles, increased by many small mountain streams. At Canyon, Colo., it emerges from the Rocky Mountain front and takes a general easterly direction across the great plains of Colorado, where most of the water is diverted for irrigation. It flows east across Kansas to the center of the State, thence southeast through Indian Territory and Arkansas into the Mississippi River, about 25 miles north of Greenville, Miss. Throughout the mountainous area above Canyon the discharge increases, but as soon as the river emerges onto the Great Plains the water is gradually diverted by lines of canals, so that by the time the Kansas line is reached the river is usually dry during the summer. Among its tributaries the Neosho (called the Grand in Indian Territory) and the Verdigris rivers drain southeastern Kansas and flow south in nearly parallel courses, joining the Arkansas about 3 miles apart, west of Tahlequah, Ind. T. The Walnut River is a small tributary from the north, flowing into the Arkansas at Arkansas City, Kans. The north fork of the Canadian River rises in the northeastern part of New Mexico, and flows east through Oklahoma and Indian Territory into the Canadian River about 40 miles above its mouth. The following is a list of the stations in the Arkansas River drainage basin:

Canadian River (North Fork) near Elreno, Okla.
Neosho River at Iola, Kans.
Verdigris River near Liberty, Kans.
Walnut River at Arkansas City, Kans.
Arkansas River at Arkansas City, Kans.

Arkansas River at Hutchinson, Kans.
Arkansas River at Dodge City, Kans.
Arkansas River at Syracuse, Kans.
Arkansas River at Barton, Colo.
Arkansas River near Rockyford, Colo.
Arkansas River near Nepesta, Colo.
Arkansas River at Pueblo, Colo.
Arkansas River near Canyon, Colo.
Arkansas River at Salida, Colo.

CANADIAN RIVER (NORTH FORK) NEAR ELRENO, OKLA.

This station was established October 27, 1902, by W. G. Russell, and is located at the highway bridge, 2 miles north of Elreno, Okla. The gage is of the usual wire type, with a scale board graduated to feet and tenths, and nailed to the railing of the bridge. The bench mark is the top of a steel cylinder on the north side of the bridge. Its elevation is 11.3 feet above the zero of the gage. The initial point for sounding is on the right bank. The channel both above and below the station is straight for about 200 feet; the right bank is high and the left bank is low; both banks are liable to overflow. The bed of the stream is sandy, and somewhat shifting. The observer is G. G. Sudermann, who reads the gage once daily.

The following discharge measurement was made in 1902:

October 27: Gage height, 2.00 feet; discharge, 23 second-feet.

Daily gage height, in feet, of Canadian River (North Fork), near Elreno, Okla.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	2.00	2.60	12	.....	2.10	2.50	23	.....	2.50	2.60
2	.....	2.20	2.50	13	.....	2.30	2.50	24	.....	3.00	2.60
3	.....	2.10	2.40	14	.....	2.20	2.80	25	.....	2.80	2.70
4	.....	2.10	2.40	15	.....	2.20	2.80	26	.....	2.60	2.80
5	.....	2.10	2.40	16	.....	2.20	2.70	27	2.00	2.50	2.80
6	.....	2.10	2.50	17	.....	2.30	2.70	28	2.00	2.50	2.80
7	.....	2.10	2.50	18	.....	2.30	2.70	29	2.00	2.50	2.40
8	.....	2.10	2.50	19	.....	2.30	2.60	30	2.00	2.50	2.40
9	.....	2.10	2.50	20	.....	2.30	2.60	31	2.00	.....	2.60
10	.....	2.10	2.50	21	.....	3.45	2.60				
11	.....	2.10	2.50	22	.....	2.80	2.60				

NEOSHO RIVER AT IOLA, KANS.

The station was established in July, 1895, and is located at the highway bridge 1 mile west of the city of Iola, Kans. The gage is fastened to the head gates of the flume about 90 feet above the bridge. The bench mark is the heads of three large nails driven into the cross-piece of the flume, and is 13.30 feet above the datum of the gage.

The observer is Thomas J. Staley.

The following discharge measurements were made by W. G. Russell during 1902:

April 26: Gage height, 3.00 feet; discharge, 512 second-feet.
May 29: Gage height, 12.00 feet; discharge, 15,216 second-feet.
June 19: Gage height, 4.50 feet; discharge, 1,312 second-feet.
July 29: Gage height, 7.70 feet; discharge, 6,995 second-feet.
August 25: Gage height, 16.50 feet; discharge, 25,246 second-feet.

Daily gage height, in feet, of Neosho River at Iola, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.00	2.70	3.15	2.90	4.00	8.00	4.50	5.15	13.50	4.65	3.35	3.60
2	2.00	2.70	4.00	2.90	3.50	7.50	4.50	4.25	12.10	4.00	3.30	3.65
3	2.10	2.70	3.50	2.90	3.50	5.75	4.50	3.00	10.50	4.50	3.35	4.85
4	2.20	2.70	3.60	2.90	3.30	5.50	4.50	2.85	6.25	10.00	3.30	5.70
5	2.30	2.70	3.00	2.90	3.30	13.00	4.50	2.80	5.25	14.25	3.15	4.50
6	2.30	2.70	3.00	2.90	6.10	15.25	4.50	2.65	6.15	11.75	3.00	3.95
7	2.50	2.70	3.00	2.90	5.25	16.75	4.50	2.50	7.35	11.75	3.00	3.90
8	2.50	2.70	3.00	2.85	3.50	17.90	5.00	2.50	8.40	10.75	3.00	3.65
9	2.50	2.70	3.00	2.80	3.00	17.90	5.00	2.40	6.75	8.75	3.00	3.50
10	2.50	2.70	3.00	2.80	3.00	20.50	5.00	2.40	5.90	6.65	3.00	3.50
11	2.50	2.80	2.90	2.80	2.90	21.25	4.70	2.40	5.25	6.10	3.00	3.50
12	2.50	2.80	3.00	2.80	2.80	15.50	4.70	2.40	4.40	6.20	3.00	3.50
13	2.50	2.80	3.10	2.80	2.80	5.55	4.50	2.40	3.50	5.50	3.00	3.50
14	2.50	2.80	3.00	2.80	2.80	5.00	4.50	2.40	3.40	5.40	5.00	3.60
15	2.50	2.80	2.80	2.80	2.80	5.00	4.25	2.90	3.40	5.30	5.00	4.50
16	2.50	3.00	2.80	2.80	4.25	5.00	4.00	2.90	3.40	5.20	4.50	4.65
17	2.50	3.00	2.90	2.80	6.55	5.00	4.00	2.50	3.00	5.50	4.30	3.85
18	2.50	3.00	2.90	2.80	5.20	4.50	4.00	2.50	3.00	5.50	4.30	3.90
19	2.50	3.00	2.70	2.80	4.25	4.50	4.50	3.00	3.10	5.20	4.20	4.00
20	2.60	3.00	2.70	2.80	3.25	11.50	6.00	5.85	3.20	5.40	4.20	7.25
21	2.60	3.00	3.00	2.80	4.50	15.50	5.00	9.75	3.50	5.50	4.00	8.00
22	2.70	3.00	3.00	2.80	11.50	15.00	4.00	11.50	6.00	4.75	3.80	7.00
23	2.70	3.00	2.80	2.80	12.00	10.50	4.00	13.50	8.50	4.50	3.80	6.50
24	2.70	3.00	2.80	3.00	12.75	8.25	4.00	16.25	8.50	4.25	3.70	6.00
25	2.75	3.00	2.90	4.00	12.35	7.65	3.50	16.25	12.25	4.20	3.70	5.00
26	2.70	3.15	2.90	3.00	13.50	5.50	3.50	15.25	7.75	4.50	3.70	4.65
27	2.70	3.60	2.90	3.00	12.50	5.00	3.50	15.25	6.00	4.00	3.60	4.50
28	2.70	3.60	3.00	6.50	12.60	4.50	4.00	14.15	5.00	4.00	3.60	4.50
29	2.70	.....	3.00	5.75	12.00	4.50	7.55	7.50	5.00	3.65	3.60	4.20
30	2.70	.....	2.80	4.25	9.00	4.50	6.00	5.25	4.90	3.50	3.60	4.00
31	2.70	.....	2.80	.....	6.25	.....	5.40	12.25	.....	3.40	.....	3.90

Rating table for Neosho River at Iola, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	190	4.8	2,360	7.6	6,780	11.0	13,100
2.2	260	5.0	2,600	7.8	7,140	11.5	14,150
2.4	330	5.2	2,900	8.0	7,500	12.0	15,200
2.6	400	5.4	3,200	8.2	7,860	12.5	16,300
2.8	490	5.6	3,500	8.4	8,220	13.0	17,400
3.0	580	5.8	3,800	8.6	8,580	13.5	18,500
3.2	700	6.0	4,100	8.8	8,940	14.0	19,600
3.4	850	6.2	4,420	9.0	9,300	15.0	21,800
3.6	1,000	6.4	4,740	9.2	9,660	16.0	24,000
3.8	1,200	6.6	5,060	9.4	10,020	17.0	26,200
4.0	1,400	6.8	5,380	9.6	10,380	18.0	28,400
4.2	1,640	7.0	5,700	9.8	10,740	19.0	30,600
4.4	1,880	7.2	6,060	10.0	11,100	20.0	32,800
4.6	2,120	7.4	6,420	10.5	12,100	21.0	35,000

Estimated monthly discharge of Neosho River at Iola, Kans.

[Drainage area, 3,670 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	467	190	370	22,750	0.10	0.12
February	1,000	445	549	30,470	.15	.16
March	1,400	445	601	36,954	.16	.18
April	4,900	490	836	49,745	.23	.26
May	18,500	490	5,585	343,408	1.52	1.75
June	35,550	2,000	11,694	695,841	3.19	3.56
July	6,690	925	2,169	133,367	.59	.68
August	24,550	330	6,382	392,414	1.74	2.01
September	18,500	580	4,962	295,259	1.35	1.51
October	20,150	850	4,689	288,315	1.28	1.48
November	2,600	580	1,119	66,585	.30	.33
December	7,500	925	2,227	136,933	.61	.70
The year	35,550	190	3,432	2,492,041	.94	12.74

VERDIGRIS RIVER NEAR LIBERTY, KANS.

The station was established in August, 1895, and is located at a wagon bridge about 250 feet below McTaggart's mill dam, about 3 miles southwest of the town of Liberty, Kans. The gage is a vertical

timber fastened to the floor of the mill. Bench mark No. 1 is the heads of three large nails in the flume, and is at an elevation of 12.46 feet above the zero of the gage. Bench mark No. 2 is the head of a spike in the root of a cottonwood tree 40 feet south of the gage, and is at an elevation of 10.98 feet above gage datum. The bed is rocky, composed of gravel and subject to very little change. In 1900 a new bench mark was established, consisting of 3 nails driven horizontally into a root on the river side of a cottonwood tree 40 feet south of the gage, the nails being 8 inches below a sandstone rock which protrudes from a hollow in the tree. Its elevation is 11.88 feet above the zero of the old gage.

The observer is C. Fienen.

During 1902 the following discharge measurements were made by W. G. Russell:

April 27: Gage height, 3.10 feet; discharge, 284 second-feet.
May 30: Gage height, 5.50 feet; discharge, 1,822 second-feet.
June 20: Gage height, 9.75 feet; discharge, 6,192 second-feet.
August 24: Gage height, 8.70 feet; discharge, 5,136 second-feet.

Daily gage height, in feet, of Verdigris River near Liberty, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.00	1.90	3.85	3.00	2.60	5.20	5.70	3.60	14.25	4.80	3.20	3.80
2	2.00	1.90	3.75	2.90	3.30	8.35	5.30	3.25	14.00	4.60	3.25	4.15
3	2.00	1.90	3.70	2.90	4.25	7.25	4.45	3.05	7.00	4.65	3.50	6.20
4	2.00	1.90	3.45	2.90	3.30	11.90	4.05	2.80	4.65	6.80	4.10	5.90
5	2.00	1.90	2.80	2.90	5.25	26.25	3.75	2.65	4.20	15.20	5.20	5.35
6	2.00	1.90	2.70	2.90	6.95	31.75	3.55	2.60	7.90	16.85	4.30	4.65
7	2.00	1.90	2.60	2.80	9.45	33.37	3.35	2.50	10.75	11.05	3.95	4.25
8	2.00	1.90	2.55	2.70	6.20	32.10	6.40	2.50	7.50	6.10	3.85	4.10
9	2.00	1.90	2.50	2.70	5.00	29.50	9.40	2.70	4.75	5.40	3.80	4.00
10	2.00	1.90	2.40	2.70	4.05	13.25	6.10	3.10	3.75	4.95	3.70	4.00
11	2.00	1.90	2.40	2.65	3.60	6.25	5.80	2.95	3.60	4.75	3.55	4.00
12	1.90	1.90	2.50	2.65	3.35	5.40	4.35	2.95	3.40	4.55	3.45	4.00
13	1.90	1.90	2.40	2.60	3.25	4.90	4.10	2.75	3.35	4.40	8.20	4.00
14	1.90	1.90	2.40	2.60	3.05	4.70	3.85	2.60	3.30	4.25	12.70	4.85
15	1.90	1.90	2.40	2.60	3.05	6.65	3.65	2.60	3.15	4.10	14.20	11.25
16	1.90	1.90	2.80	2.60	3.15	8.30	3.45	2.50	3.00	4.05	7.90	10.10
17	1.90	1.90	2.75	2.65	2.90	4.90	3.30	2.40	3.05	3.95	5.80	6.40
18	1.90	1.90	2.70	2.65	2.75	5.35	3.20	2.40	3.05	3.75	5.00	5.40
19	1.90	1.90	2.60	2.60	2.80	10.65	4.30	2.30	3.00	3.65	4.65	5.40
20	1.90	1.90	2.50	2.60	2.90	12.05	4.05	2.25	3.50	3.60	4.50	7.05
21	1.90	1.90	2.50	2.60	3.40	14.10	5.35	2.70	4.75	3.60	4.40	10.75
22	1.90	1.90	2.50	2.55	13.30	15.05	4.40	3.45	5.25	3.60	4.35	8.45
23	1.90	1.90	2.60	2.55	22.70	14.90	3.90	3.65	5.40	3.55	4.25	6.10
24	1.90	2.25	3.55	2.65	28.05	9.10	3.95	7.90	13.00	3.45	4.45	5.45
25	1.90	2.75	3.40	3.60	28.67	5.15	3.45	10.00	20.75	3.40	4.65	5.10
26	1.90	5.60	3.35	3.90	25.25	4.70	3.00	11.95	17.90	3.30	4.55	4.75
27	1.90	5.05	3.55	3.10	22.30	4.40	2.90	8.25	7.00	3.25	4.40	4.55
28	1.90	4.70	3.70	2.85	19.00	4.20	2.90	5.40	5.75	3.20	4.30	4.30
29	1.90	.....	3.50	2.65	9.10	4.75	2.95	4.70	5.15	3.20	3.95	4.30
30	1.90	.....	3.25	2.60	5.40	6.05	3.80	3.70	5.00	3.20	3.85	4.30
31	1.90	.....	3.15	.....	5.00	.....	3.80	8.20	.....	3.20	.....	4.20

Rating table for Verdigris River near Liberty, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	2	5.2	1,520	9.2	4,375	18.0	12,300
1.4	5	5.4	1,650	9.4	4,525	19.0	13,500
1.6	10	5.6	1,780	9.6	4,680	20.0	14,700
1.8	27	5.8	1,920	9.8	4,840	21.0	15,900
2.0	55	6.0	2,060	10.0	5,000	22.0	17,150
2.2	90	6.2	2,200	10.2	5,160	23.0	18,500
2.4	140	6.4	2,340	10.4	5,320	24.0	19,900
2.6	205	6.6	2,480	10.6	5,480	25.0	21,300
2.8	280	6.8	2,620	10.8	5,640	26.0	22,700
3.0	368	7.0	2,760	11.0	5,801	27.0	24,100
3.2	464	7.2	2,901	11.2	5,963	28.0	25,500
3.4	560	7.4	3,043	11.4	6,126	29.0	26,900
3.6	660	7.6	3,188	11.6	6,290	30.0	28,300
3.8	760	7.8	3,334	11.8	6,454	31.0	29,700
4.0	860	8.0	3,480	12.0	6,619	32.0	31,100
4.2	960	8.2	3,626	13.0	7,458	33.0	32,500
4.4	1,060	8.4	3,775	14.0	8,300	34.0	33,950
4.6	1,164	8.6	3,925	15.0	9,150	35.0	35,450
4.8	1,280	8.8	4,075	16.0	10,100	36.0	36,950
5.0	1,400	9.0	4,225	17.0	11,150		

Estimated monthly discharge of Verdigris River near Liberty, Kans.

[Drainage area, 3,067 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	55	40	45	2,767	0.01	0.01
February	1,780	40	204	11,330	.07	.07
March	785	140	357	21,951	.12	.14
April	810	187	268	15,947	.09	.10
May	26,438	205	5,395	331,718	1.76	2.03
June	33,018	960	7,893	469,666	2.57	2.87
July	4,525	320	1,050	64,562	.34	.39
August	6,577	100	1,051	64,623	.34	.39
September	15,650	368	2,935	174,645	.96	1.07
October	11,080	464	1,706	104,898	.56	.65
November	8,470	464	1,598	95,088	.52	.58
December	6,433	685	1,852	113,875	.60	.69
The year	33,018	40	2,030	1,471,070	.66	8.99

WALNUT RIVER AT ARKANSAS CITY, KANS.

This station was established September 21, 1902, by W. G. Russell, and is located on the Madison avenue highway bridge one-half mile east of Arkansas City, Kans. The gage is of the usual wire type, with the scaleboard graduated to feet and tenths; it is read daily by D. T. Burton. The bench mark is the lower edge of the fifth rivet from the top in the upper row on the fourth section of the west side of the south pier. The initial point for sounding is on the right bank. The channel both above and below the station is straight, and the river is sluggish; both the right and left bank are high; the bed of the stream is sandy and shifting.

The following discharge measurements were made during 1902 by W. G. Russell:

September 24: Gage height, 10.15 feet; discharge, 3,899 second-feet.
October 20: Gage height, 4.90 feet; discharge, 182 second-feet.

Daily gage height, in feet, of Walnut River at Arkansas City, Kans.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.														
1		5.30	5.05	4.45	12		4.45	4.60	4.45	23		4.10	4.20	5.90
2		5.65	5.00	4.40	13		4.40	4.70	4.40	24	10.30	4.20	4.30	6.15
3		6.10	4.45	4.30	14		4.30	4.60	4.65	25	10.40	4.00	4.40	6.20
4		5.65	4.60	4.40	15		4.40	4.40	5.25	26	7.30	4.30	4.30	6.60
5		8.75	5.00	4.30	16		4.10	4.30	5.40	27	6.40	4.20	4.30	5.75
6		9.45	5.10	4.30	17		4.10	4.40	5.50	28	6.10	4.00	4.20	5.70
7		6.55	5.05	4.40	18		4.00	4.50	5.60	29	6.00	4.10	4.30	5.65
8		6.00	5.10	4.40	19		4.20	4.60	5.60	30	4.40	4.05	4.40	5.60
9		5.20	5.20	4.30	20		4.10	4.50	5.55	31		4.30		5.70
10		5.10	5.10	4.30	21		4.30	4.40	5.70					
11		5.00	5.00	4.40	22		4.20	4.45	5.80					

ARKANSAS RIVER AT ARKANSAS CITY, KANS.

This station was established September 23, 1902, by W. G. Russell. It is located on the Chestnut avenue highway bridge, one-half mile west of Arkansas City, Kans. The gage is a painted staff graduated to feet and tenths, spiked to the west side of the south pile of the second bent on Chestnut avenue. The bench mark is the top of the cap on the pile which carries the gage. Its elevation is 17.2 feet above zero of the gage. The initial point for sounding is on the left bank. The channel is straight for about 200 feet both above and below the station; both banks are low and liable to overflow; the bed of the river is sandy and shifting. The observer is D. T. Burton, who reads the gage daily.

The following discharge measurements were made during 1902:

September 23: Gage height, 4.70 feet; discharge, 1,008 second-feet.
October 20: Gage height, 3.80 feet; discharge, 218 second-feet.

Daily gage height, in feet, of Arkansas River at Arkansas City, Kans.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1	.....	4.10	4.40	3.40	17	.....	4.00	3.50	3.70
2	.....	4.30	4.10	3.40	18	.....	3.20	3.60	3.80
3	.....	4.40	3.70	3.50	19	.....	3.00	3.70	3.70
4	.....	4.45	3.80	3.40	20	.....	3.20	3.70	3.70
5	.....	4.50	3.60	3.30	21	.....	3.10	3.60	3.60
6	.....	4.55	3.30	3.40	22	.....	3.30	3.50	3.35
7	.....	4.50	3.40	3.45	23	4.70	3.40	3.60	3.25
8	.....	4.45	3.45	3.45	24	4.30	3.55	3.50	3.20
9	.....	4.55	3.65	3.50	25	4.20	4.10	3.40	3.10
10	.....	4.30	3.60	3.40	26	4.10	4.00	3.50	3.00
11	.....	4.55	3.50	3.45	27	4.10	4.10	3.60	2.70
12	.....	4.40	3.60	3.40	28	4.10	4.20	3.50	2.80
13	.....	4.20	3.70	3.40	29	4.00	4.10	3.40	2.75
14	.....	4.30	3.60	3.50	30	4.05	4.10	3.30	2.65
15	.....	4.10	3.40	3.60	31	.....	4.20	.....	2.65
16	.....	4.15	3.60	3.70					

ARKANSAS RIVER AT HUTCHINSON, KANS.

The Arkansas River, after crossing the Kansas and Colorado State line, is not systematically measured until Hutchinson, in about the center of the State, is reached. The station here was established May 13, 1895, and is located at the wagon bridge at the south end of Main street. The gage consists of an oak timber spiked to a pile a few feet above the bridge. Bench mark No. 1 is the upper crosspiece of the pier guard, with an elevation of 8.35 feet above zero of the gage. Bench mark No. 2 is the top of the iron doorsill of the first brick building next to the river, and its elevation is 8.12 feet above gage datum. The channel is straight for some distance above and below the bridge; the bed is sandy and very shifting, necessitating frequent discharge measurements and soundings. At time of low water the stream subdivides into a number of threads. Measurements of discharge are made from the bridge at times of high water, and at low water they can be made by wading.

The observer is Daniel Lauer.

Discharge measurements made on Arkansas River at Hutchinson, Kans.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 25	W. G. Russell	1.10	39
May 31	do	1.50	155
June 3	do	4.15	5,057
June 4	do	3.75	3,824
June 18	do	2.05	550
July 18	do	2.55	1,066
August 23	do	2.40	1,117
November 25	do	1.20	95

Daily gage height, in feet, of Arkansas River at Hutchinson, Kans.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.20	1.20	2.00	1.25	1.00	4.42	2.15	1.80	1.70	2.30	1.30	1.10
2	1.20	2.00	2.00	1.25	1.00	4.60	2.40	1.60	1.70	2.10	1.30	1.10
3	1.25	(a)	2.00	1.25	1.00	4.12	2.40	1.60	1.60	2.00	1.30	1.10
4	1.25	2.00	2.00	1.20	1.10	3.72	2.40	1.55	1.50	1.95	1.30	1.10
5	1.25	2.00	1.80	1.20	1.10	3.57	2.15	1.50	1.55	1.85	1.30	1.10
6	1.20	2.00	1.60	1.20	1.10	3.05	2.05	1.45	1.60	1.75	1.25	1.10
7	1.20	(a)	1.50	1.20	1.10	2.82	2.05	1.40	1.65	1.70	1.25	1.10
8	1.15	2.00	1.40	1.20	1.05	2.70	2.00	1.40	1.45	1.65	1.25	1.20
9	1.10	1.20	1.35	1.20	1.05	2.62	1.95	1.40	1.45	1.65	1.20	1.30
10	1.05	(a)	1.30	1.20	1.05	2.52	1.95	1.40	1.40	1.65	1.20	1.30
11	1.00	1.20	1.30	1.20	1.05	2.45	1.90	1.90	1.40	1.60	1.20	1.30
12	1.10	1.20	1.25	1.15	1.00	2.40	1.85	2.45	1.35	1.50	1.20	1.30
13	1.10	.....	1.25	1.15	1.00	2.32	2.10	2.20	1.35	1.50	1.25	1.30
14	1.05	1.20	1.20	1.15	1.20	2.22	2.50	2.10	1.35	1.50	1.30	1.30
15	1.05	.....	1.15	1.15	1.30	2.10	2.55	2.00	1.30	1.45	1.25	1.30
16	1.00	1.20	1.10	1.15	1.20	2.00	2.60	1.95	1.30	1.45	1.20	1.30
17	1.00	(a)	1.10	1.15	1.25	1.95	2.60	1.85	1.30	1.40	1.20	1.30
18	1.00	1.20	1.10	1.15	1.20	2.15	2.50	1.80	1.25	1.35	1.20	1.30
19	1.00	(a)	1.10	1.15	1.15	2.20	2.15	1.75	1.25	1.35	1.20	1.30
20	1.00	1.20	1.10	1.15	1.15	2.20	1.95	1.75	1.20	1.35	1.20	1.40
21	1.25	(a)	1.10	1.10	1.30	2.25	1.70	2.45	1.25	1.35	1.20	a1.50
22	1.25	1.20	1.15	1.10	1.75	2.30	1.70	2.50	1.25	1.35	1.20	a1.50
23	1.25	2.00	1.20	1.10	2.00	2.25	1.70	2.35	1.35	1.30	1.20	a1.50
24	1.25	2.00	1.20	1.05	2.00	2.45	1.70	2.40	1.30	1.30	1.20	a1.50
25	1.20	2.00	1.20	1.05	1.70	2.50	1.75	2.50	1.25	1.30	1.20	a1.50
26	1.20	2.00	1.25	1.05	1.55	2.40	1.75	2.40	1.25	1.30	1.20	a1.50
27	(a)	2.00	1.30	1.05	1.40	2.30	1.80	2.35	1.25	1.30	1.10	a1.50
28	1.20	2.00	1.30	1.00	1.50	2.25	1.90	2.25	2.00	1.30	1.10	1.50
29	1.20	.....	1.30	1.00	1.45	2.25	2.00	2.10	2.15	1.30	1.10	1.40
30	(a)	.....	1.30	1.00	1.50	2.15	2.00	2.00	2.30	1.30	1.10	1.40
31	1.20	.....	1.30	.....	3.90	.....	1.90	1.80	.....	1.30	.....	1.40

a Frozen.

Rating table for Arkansas River at Hutchinson, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	20	1.8	325	2.8	1,640	3.8	4,080
.9	30	1.9	400	2.9	1,820	3.9	4,340
1.0	40	2.0	475	3.0	2,000	4.0	4,600
1.1	60	2.1	600	3.1	2,260	4.1	4,860
1.2	80	2.2	725	3.2	2,520	4.2	5,120
1.3	100	2.3	850	3.3	2,780	4.3	5,380
1.4	125	2.4	975	3.4	3,040	4.4	5,640
1.5	150	2.5	1,100	3.5	3,300	4.5	5,900
1.6	200	2.6	1,280	3.6	3,560	4.6	6,160
1.7	250	2.7	1,460	3.7	3,820		

Estimated monthly discharge of Arkansas River at Hutchinson, Kans.

[Drainage area, 34,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	90	40	69	4,243	0.002	0.002
February	475	80	263	14,606	.008	.008
March	475	60	148	9,100	.004	.005
April	90	40	68	4,046	.002	.002
May	4,340	40	254	15,618	.008	.009
June	6,160	438	1,583	94,195	.047	.052
July	1,280	288	605	37,190	.018	.021
August	1,100	125	510	31,359	.015	.017
September	850	80	184	10,949	.005	.006
October	850	100	208	12,789	.006	.007
November	100	60	83	4,939	.002	.003
December	150	60	106	6,518	.003	.004
The year	6,160	40	340	245,552	.010	.136

ARKANSAS RIVER AT DODGE, KANS.

This station was established November 28, 1902, by W. G. Russell, and is located one-fourth mile south of Dodge, on the highway bridge. The gage is a plain staff graduated to feet and tenths, and nailed to the upstream pile of the twelfth bent at the north end of the bridge. The initial point for sounding is on the left bank. The channel both above and below the station is straight for about 100 feet; both banks are low and liable to overflow; the bed of the stream is sandy and shifting. The observer is Alexander Alter, who reads the gage once each day.

The following discharge measurement was made in 1902:

November 28: Gage height, 1.55 feet; discharge, 45 second-feet.

Daily gage height, in feet, of Arkansas River at Dodge, Kans.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.											
1		1.45	9		1.55	17		1.25	25		1.55
2		1.55	10		1.35	18		1.25	26		1.65
3		2.00	11		1.65	19		1.25	27		1.65
4		1.35	12		1.25	20		1.15	28	1.55	1.45
5		1.35	13		1.45	21		1.45	29	1.10	1.65
6		1.25	14		1.65	22		1.55	30	1.45	1.65
7		1.50	15		1.00	23		1.45	31		1.55
8		1.65	16		1.00	24		1.55			

ARKANSAS RIVER AT SYRACUSE, KANS.

This station, established August 21, 1902, by W. G. Russell, is located on the highway bridge 1 mile south of Syracuse, Kans. The gage is a plain staff graduated to feet and tenths, fastened to the east pile of the bent 283 feet south of the north end of the bridge. The initial point for sounding is on the left bank. The channel above and below the station is straight and the water is sluggish. The right bank is low and liable to overflow; the left bank is high, and the bed of the stream is sandy and shifting. The bench mark is on the top of the east end of the first sill at the north end of the bridge. Its elevation is 13.45 feet above the zero of the gage. The gage is read daily by Clyde S. Welborn.

The following discharge measurements were made during 1902:

August 21: Gage height, 2.05 feet; discharge, 99 second-feet.
August 30: Gage height, 3.00 feet; discharge, 909 second-feet.
November 9: Gage height, 1.80 feet; discharge, 42 second-feet.
November 26: Gage height, 1.60 feet; discharge, 19 second-feet.

Daily gage height, in feet, of Arkansas River at Syracuse, Kans.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.					
1	.....	2.70	1.75	1.70	1.80
2	.....	2.70	1.75	1.70	1.70
3	.....	2.65	1.80	1.70	1.70
4	.....	2.55	2.00	1.70	1.80
5	.....	2.50	2.00	1.70	1.70
6	.....	2.50	1.95	1.70	1.70
7	.....	2.45	1.95	1.70	1.80
8	.....	2.45	1.90	1.70	1.80
9	.....	2.40	1.90	1.80	1.90
10	.....	2.35	1.85	1.80	1.80
11	.....	2.30	1.80	1.80	1.80
12	.....	2.25	1.80	1.80	1.80
13	.....	2.15	1.80	1.80	1.80
14	.....	2.05	1.80	1.80	1.80
15	.....	1.95	1.80	1.80	1.80
16	.....	1.95	1.80	(a)	1.80
17	.....	1.95	1.80	.....	1.80
18	.....	1.90	1.80	.....	1.80
19	.....	1.90	1.80	.....	1.80
20	.....	1.90	1.80	.....	1.80
21	2.05	1.90	1.80	.....	1.90
22	2.05	1.85	1.75	.....	2.00
23	2.00	1.85	1.75	.....	2.00
24	2.00	1.85	1.75	.....	2.00
25	1.90	1.80	1.75	.....	2.00
26	2.05	1.80	1.70	1.60	2.00
27	3.05	1.80	1.70	1.80	1.90
28	3.85	1.75	1.70	1.70	2.00
29	3.45	1.75	1.70	1.80	2.10
30	3.00	1.75	1.70	1.80	2.00
31	2.85	.....	1.70	.....	2.00

[a] No observer.

Rating table for Arkansas River at Syracuse, Kans., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	20	2.2	190	2.8	680	3.4	1,315
1.7	30	2.3	250	2.9	780	3.5	1,430
1.8	40	2.4	330	3.0	880	3.6	1,545
1.9	60	2.5	410	3.1	980	3.7	1,660
2.0	80	2.6	500	3.2	1,090	3.8	1,775
2.1	130	2.7	590	3.3	1,200	3.9	1,890

Estimated monthly discharge of Arkansas River at Syracuse, Kans.

[Drainage area, 24,960 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
August 21 to 31	.....	.....	[a] 571	[a] 12,459	[a] 0.023	[a] 0.009
September	590	35	197	11,722	.008	.009
October	80	30	43	2,644	.002	.002
November	.....	.....	[b] 34	[c] 2,023	[c] .001	[c] .002
December	130	30	54	3,320	.002	.003

[a] 11 days. [b] 20 days. [c] 30 days.

ARKANSAS RIVER AT BARTON, COLO.

This station was established May 2, 1901, at the railroad bridge one-half mile east of Barton or Byron, which is the name of the railroad station on the Atchison, Topeka and Santa Fe Railway. Throughout this region the bed of the stream is broad and sandy, and the channel is shifting. This point was selected as the most available place for determining, approximately, the discharge of the Arkansas at a point near the Colorado-Kansas line. The rod consists of a vertical 2 by 4 inch piece of timber 7 feet long, nailed to a pile on the downstream side of the railroad bridge at the lowest point in the channel. No bench mark was established, but the rod was spiked at the foot marks to the pile. The channel is extremely shifting, and there may be at times many different channels. The initial point for soundings is the right bank. The observer was Harry Hunt, postmaster at Barton.

The observations at this station were discontinued in May, 1902, for the reason that the channel had changed and the conditions were unfavorable for securing reliable data.

Daily gage height, in feet, of Arkansas River at Barton, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1902.						1902.					
1	1.15	1.30	0.90	0.30	0.10	17	1.30	1.50	0.20	0.20	.....
2	1.20	1.30	.80	.30	.15	18	1.20	1.50	.30	.20	.....
3	1.20	1.40	.80	.20	.15	19	1.20	1.40	.35	.25	.....
4	1.30	1.50	.70	.10	.....	20	1.15	1.40	.35	.25	.....
5	1.30	1.50	.70	.10	.....	21	1.15	1.40	.35	.20	.....
6	1.30	1.50	.50	.05	.....	22	1.10	1.30	.35	.20	.....
7	1.40	1.50	.40	.05	.....	23	1.10	1.30	.45	.20	.....
8	1.40	1.50	.40	.05	.....	24	1.10	1.20	.50	.10	.....
9	1.50	1.50	.40	.05	.....	25	1.10	1.00	.40	.10	.....
10	1.50	1.60	.40	.05	.....	26	1.00	1.00	.30	.05	.....
11	1.50	1.70	.30	.05	.....	27	1.00	1.00	.25	.05	.....
12	1.60	1.70	.30	.20	.....	28	1.00	.90	.30	.05	.....
13	1.50	1.70	.30	.30	.....	29	1.10	.....	.30	.05	.....
14	1.40	1.70	.20	.35	.....	30	1.10	.....	.35	.10	.....
15	1.40	1.60	.20	.35	.....	31	1.20	.....	.30	.....	.....
16	1.30	1.60	.20	.30	.....						

ARKANSAS RIVER NEAR ROCKYFORD, COLO.

The old station was located 2 miles northeast of Rockyford, Colo., and was established May 3, 1897. The gage consisted of a vertical 1 by 3 inch timber notched in tenths and securely nailed to the pile protection to the abutment of the wagon bridge at the left side of the stream, upper side of the bridge. The initial point for soundings was on the left bank at the water's edge. Both banks are high and liable to overflow only at very high water. The channel is straight for about 300 feet above and below the station. The bed is sandy and shifting. This station was abandoned April 7, 1900.

A new station was established by R. W. Hawley on April 19, 1901, at a point 3½ miles northwest from Rockyford station on the Atchison, Topeka and Santa Fe Railway. A steel cable was stretched across the river and supplied with a car, and an inclined timber gage rod was bolted into the shale on the north side of the river and marked. The bench mark consists of a cut in a tree at the initial point level with a 10-foot mark on the rod. The records were kept through the courtesy of the American Beet Sugar Company, Fred Chappell, agriculturist, taking the reading. The channel is fairly favorable for good results, being at what is known as the old ford. The bottom is of shale and usually free from sand, although filled in to a certain extent at some stages. Gagings may be made either by means of the cable and car or by wading. The point is of especial importance, owing to the fact that it is one of the few places on the Arkansas River where the channel is at all permanent.

Daily gage height, in feet, of Arkansas River near Rockyford, Colo.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1902.				1902.			
1	1.80	2.00	2.00	17	1.50	2.00	2.50
2	1.70	2.20	2.20	18	1.50	2.00	2.00
3	1.80	2.50	2.00	19	1.50	2.00	2.00
4	1.80	2.50	1.80	20	1.60	2.00	1.80
5	1.80	2.50	2.20	21	1.50	2.00	2.20
6	1.90	2.40	2.00	22	1.60	2.00	2.20
7	1.90	2.30	2.00	23	1.60	1.90	1.80
8	1.90	2.20	1.80	24	1.50	1.80	2.20
9	1.80	2.40	2.00	25	1.50	2.20	2.00
10	1.70	2.60	1.80	26	1.60	2.00	1.80
11	1.70	2.60	2.20	27	1.60	2.20	2.20
12	1.50	2.50	2.30	28	1.60	2.00	1.80
13	1.60	2.70	2.20	29	1.60	.....	1.80
14	1.50	2.40	2.00	30	1.90	.....	2.20
15	1.50	2.50	2.20	31	1.90	.....	2.00
16	1.50	2.00	2.50				

Rating table for Arkansas River near Rockyford, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet*	*Second-feet.*	*Feet.*	*Second-feet.*
--0.2	25	1.2	181	2.6	1,665	4.0	4,420
.0	32	1.4	238	2.8	2,035	4.2	4,820
.2	43	1.6	343	3.0	2,424	4.4	5,220
.4	56	1.8	510	3.2	2,820	4.6	5,620
.6	73	2.0	735	3.4	3,220	4.8	6,020
.8	101	2.2	1,009	3.6	3,620		
1.0	137	2.4	1,321	3.8	4,020		

Estimated monthly discharge of Arkansas River near Rockyford, Colo.

[Drainage area, 11,440 square miles.]

Month.	Discharge in second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
January	616	282	402	24,718	0.035	0.04
February	1,848	510	1,081	60,036	.094	.10
March	1,489	510	828	50,896	.072	.08

ARKANSAS RIVER NEAR NEPESTA, COLO.

The original station, established September 8, 1897, is located 1,000 feet north of Nepesta, Colo., at a wagon bridge, 200 feet below the Atchison, Topeka and Santa Fe Railroad. The gage consists of a vertical timber graduated to feet and tenths, securely fastened to the upstream cylinder of the bridge, on the left side of the river. The channel above and below the station is straight for several hundred feet, while the bed is sandy and shifting, and the results, therefore, are not altogether satisfactory for the purpose of making a rating table. This station was maintained by the Great Plains Water Company until December, 1900. May 1, 1901, another station was established by A. L. Fellows, assisted by C. W. Beach, at the dam and head gate of the Oxford Farmers' Canal, 1½ miles west of Nepesta. The station consists of the dam crossing the river at the head gate forming a weir, and a gage rod, consisting of a 2 by 6 inch timber, 8 feet long, fastened to an oak pile at the south end of the dam; the location being marked by spikes driven into the pile at each foot mark. The rod is graduated to feet and tenths vertically. At low stages the stream may be measured by wading, but at high stages it is necessary to use the wagon bridge at Nepesta, making the necessary allowances for inflow between the two points; this can readily be done, as the distance is only about a mile. The observer is Z. Swallow, head gate keeper of the Oxford Farmers' Canal. The station will prove of particular value, as it is near the head of irrigation district No. 17, one of the most important on the Arkansas River.

The table of the discharge of the Oxford Farmers' Canal has been furnished by their secretary, F. M. Weiland. Readings were taken only on those days when the river gage read zero.

During 1902 the following discharge measurements were made by C. W. Beach:

May 23: Gage height, 0.50 feet; discharge, 234 second-feet.
June 28: Gage height, 0.60 feet; discharge, 127[a] second-feet.

Daily gage height, in feet, of Arkansas River near Nepesta, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	0.58	.....	0.92	.....	.....	0.72	0.51	0.52
2	.61	.....	.91	.....	.....	.59	.59	.....
3	.61	0.27	.98	.....	.....	.53	.61	.....
4	.55	.62	1.05	.....	.....	.51	.61	.....
5	.54	.79	1.02	0.20	.....	.42	.59	.....
6	.63	.80	.95	.20	4.75	.39	.51	.....
7	.61	.67	.98	.59	1.55	.41	.50	.....
8	.52	.75	.95	.57	.62	.39	.49	.....

[a] Water fell 0.05 during gaging.

Daily gage height, in feet, of Arkansas River near Nepesta, Colo.—Continued.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
9	0.57	0.87	0.93	0.44	0.53	.....	0.50	.....
10	.60	.80	.85	.72	.42	.....	.51	.....
11	.59	.85	.85	1.42	.....	.....	.49	.....
12	.55	1.20	.87	1.60	.52	.....	.51	.....
13	.62	1.17	.83	.44	.50	.....	.50	.....
14	.64	1.16	.87	.41	.61	0.39	.51	.....
15	.59	1.22	.86	.39	.49	.....	.50	.....
16	.51	1.16	.87	.19	.50	.....	.50	.....
17	.49	1.21	.79	.60	.51	.....	.49	.....
18	.49	1.19	.75	1.90	.39	.....	.52	.....
19	.42	1.12	.69	1.30	.19	.....	.51	.....
20	.48	1.02	.68	.50	.....	.....	.50	.....
21	.22	.78	.64	.20	.....	.52	.50	.....
22	.27	.65	.59	.....	.....	.59	.52	.....
23	.36	.64	.61	.....	.20	.61	.52	.....
24	.36	.72	.53	.....	.44	.56	.51	.....
25	.....	.75	.56	.....	.51	.50	.50	.....
26	.....	.73	.51	.....	1.10	.49	.52	.....
27	.....	2.65	.51	.55	1.40	.48	.50	.....
28	.17	2.65	1.25	.51	1.12	.49	.50	.....
29	.17	1.72	1.73	.25	.75	.59	.50	.....
30	.17	1.22	.25	.....	.59	.59	.50	.....
31	.....	1.05	.....	.....	2.00	.....	.52	.....

Discharge of Oxford Farmers' Canal.

Date.	River gage.	Second-feet in Oxford Farmers' Canal.	Date.	River gage.	Second-feet in Oxford Farmers' Canal.
July 1	0.00	75	August 11	0.00	80
July 2	0.00	53	August 20	0.00	14
July 3	0.00	14	August 21	0.00	14
July 4	0.00	14	August 22	0.00	14
July 22	0.00	14	September 9	0.00	30
July 23	0.00	14	September 10	0.00	14
July 24	0.00	14	September 11	0.00	14
July 25	0.00	8	September 12	0.00	18
July 26	0.00	6	September 13	0.00	20
July 30	0.00	14	September 15	0.00	14
July 31	0.00	14	September 16	0.00	14
August 1	0.00	6	September 17	0.00	14
August 2	0.00	6	September 18	0.00	14
August 3	0.00	6	September 19	0.00	14
August 4	0.00	14	September 20	0.00	14
August 5	0.00	14			

April 25, 26, and 27 gage rod read zero, but no flow in canal recorded.

Rating table for Arkansas River near Nepesta, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	21	1.6	2,067	3.0	5,202	4.4	8,400
.4	61	1.8	2,506	3.2	5,658	4.6	8,860
.6	200	2.0	2,949	3.4	6,114	4.8	9,324
.8	465	2.2	3,396	3.6	6,570	5.0	9,788
1.0	815	2.4	3,844	3.8	7,026		
1.2	1,217	2.6	4,296	4.0	7,482		
1.4	1,635	2.8	4,748	4.2	7,940		

Estimated monthly discharge of Arkansas River near Nepesta, Colo.[a]

[Drainage area 9,130 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	244	0	119	7,081	0.013	0.015
May	4,409	0	936	57,552	.103	.119
June	2,352	28	566	33,679	.062	.069
July	2,727	0	312	19,184	.034	.039
August	9,208	0	643	39,537	.070	.081
September	348	0	87	5,177	.010	.011
October	211	108	129	7,932	.013	.015

[a] These figures do not include the flow of Oxford Farmers' Canal.

ARKANSAS RIVER AT PUEBLO, COLO.

This station was established in September, 1894, by A. P. Davis. Originally there were two gage rods. The main gage was located at the Santa Fe Avenue Bridge and consisted of a vertical 6 by 6 inch timber, and a 1 by 6 inch scale bolted to the abutment of the Denver and Rio Grande Railroad bridge on the left-hand side of the river, graduated to tenths of a foot. There was also a short vertical rod for extreme low water spiked to a pile about 20 feet out in the stream, reading the same as the main gage. The 12-foot mark of this gage was opposite the top of the large capstone. The rod at Victoria Avenue Bridge consisted of inclined 4 by 4 inch timbers fastened to posts set in the right bank of the stream, graduated to vertical tenths of a foot, the space between the marks being 0.242 of a foot. This rod was placed in June, 1895, for the purpose of noting the change in the slope of the water surface. The rods were read until July 10, 1898, when on account of the shifting of the bed of the river they were abandoned and a new gage was installed on the east side of the Main Street Bridge. From this bridge all the discharge measurements were made until the season of 1902.

The channel at this point is excellent, and it would be of very great value to the entire division to have a permanent station of concrete established here. The channel, which is of bowlders and gravel, is confined by high masonry walls, so that there is little change, except that it fills during low water and scours out during high water. The flow of the stream is rapid, but not too swift for accurate measurements. This station is an important one, being located near the head of the principal irrigation portion of the valley, only one ditch of importance being taken out above it in the Pueblo district, although considerable water is used in the ditches in the neighborhood of Canyon, which is in another water district. It is upon the gagings made at this point that the water superintendents and commissioners depend for distribution of water to ditches below.

Readings were made at Main street bridge until March 3, 1900, when owing to the scouring of the channel it became necessary to replace the gage by one about 60 feet below the south end of the Union avenue bridge. This gage was a 2 by 6 inch vertical timber, bolted like the former rod to the masonry wall and graduated to feet and tenths. On June 13, 1900, this rod was connected with a bench mark on the coping at the northwest corner of the Union avenue bridge, which was found to be 19.79 feet above the zero of the rod. In March, 1902, another rod exactly similar to the one last mentioned was bolted in a vertical position to the masonry wall on the right-hand side of the river about 30 feet above the south end of the Union avenue bridge. All gage heights up to July 14, 1902, were taken from the rod just below the Union avenue bridge. After July 14, 1902, the readings were taken from the rod above the bridge, the graduations on the former rod being too dim to be read at low water. A difference of 0.2 of a foot existed between the two rods when the new one was set, the new rod reading 0.2 of a foot higher than the old one. In all the discharge measurements made during 1902 the gage height was taken from the new rod above the Union avenue bridge. The observer during 1902 was T. J. Burrows, water commissioner of the Pueblo water district.

Discharge measurements of Arkansas River at Pueblo, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 25	J. E. Field	1.80	220
May 18	C. W. Beach	3.30	1,323
July 7	do	1.80	193
July 15	J. E. Field	1.60	130
August 24	M. C. Hinderlider	2.20	358
September 1	C. W. Beach	2.17	341
September 21	do	2.05	212

Daily gage height, in feet, of Arkansas River at Pueblo, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.20	4.20	2.10	1.80	2.00	2.65	1.90	1.30	2.20	2.00	2.10	2.05
2	2.20	3.70	2.10	1.80	2.00	2.60	2.20	1.40	1.90	2.00	2.10	2.10
3	2.20	3.70	2.00	1.80	2.10	2.62	2.05	1.75	2.00	2.10	2.10	2.10
4	2.30	3.50	2.00	1.80	2.30	2.80	2.05	1.80	2.00	2.10	2.10	2.20
5	2.30	3.50	1.90	1.80	2.60	2.70	2.05	8.10	2.00	2.10	2.10	2.10
6	2.20	3.50	2.00	1.80	2.60	2.70	1.80	3.00	2.00	2.10	2.10	2.16
7	2.25	3.50	2.10	1.80	2.87	2.70	1.70	2.70	2.00	2.00	2.10	2.20
8	2.25	3.70	2.00	2.00	2.95	2.70	1.70	2.30	2.00	2.00	2.10	2.20
9	2.10	3.70	2.00	2.00	2.65	2.70	1.70	2.30	2.00	2.00	2.10	2.20
10	2.10	3.50	2.05	2.00	3.00	2.55	3.35	2.30	1.90	2.00	2.10	2.10
11	2.10	3.70	2.00	2.00	3.40	2.50	2.05	2.00	1.90	2.00	2.10	2.16
12	2.15	3.80	2.00	2.00	3.40	2.70	1.70	2.00	1.90	2.00	2.00	2.10
13	2.10	3.70	2.00	2.00	3.40	2.67	1.70	2.00	2.00	2.00	2.30	2.19
14	2.10	3.40	2.00	2.00	3.40	2.65	2.00	2.00	1.90	2.00	2.00	2.10
15	2.10	3.25	2.00	2.00	3.40	2.65	1.60	1.90	2.00	2.10	2.00	2.16
16	2.10	2.20	2.00	2.00	3.40	2.60	1.60	1.90	2.00	2.10	2.00	2.10
17	2.10	2.70	2.00	1.95	3.40	2.65	2.02	1.90	2.00	2.20	2.00	2.20
18	2.30	2.20	1.90	1.90	3.40	2.50	2.30	1.90	2.00	2.20	2.00	2.20
19	2.30	2.15	1.95	1.80	3.30	2.35	2.30	1.90	2.00	2.20	2.00	2.3
20	2.20	2.10	2.00	1.80	3.05	2.30	2.20	1.80	2.00	2.20	2.00	2.10
21	2.10	2.10	2.00	1.80	2.85	2.40	2.30	1.80	2.25	2.20	2.20	2.10
22	2.05	2.10	2.00	2.00	2.60	2.30	2.10	2.35	2.15	2.20	2.20	2.20
23	2.00	1.95	2.00	2.00	2.40	2.20	2.10	2.25	2.10	2.20	2.10	2.20
24	2.10	1.80	2.00	1.90	2.30	2.20	2.00	2.30	2.10	2.20	2.10	2.2
25	2.10	1.70	2.00	1.80	2.20	2.10	1.85	2.10	2.10	2.20	2.20	2.30
26	2.15	2.10	1.90	1.90	2.40	2.00	1.80	2.30	2.10	2.20	2.15	2.20
27	2.15	2.10	1.90	2.10	2.75	1.90	1.70	3.45	1.90	2.10	2.10	2.25
28	2.20	2.10	1.90	2.00	3.20	2.20	2.20	2.10	1.90	2.10	2.10	2.20
29	2.20	.....	1.90	2.00	2.75	2.35	1.60	1.90	2.00	2.10	2.10	2.25
30	2.20	.....	1.90	2.00	2.70	2.00	1.50	2.00	2.00	2.10	2.10	2.25
31	2.20	.....	1.80	.....	2.70	.....	1.30	2.25	.....	2.10	.....	2.10

Rating table for Arkansas River at Pueblo, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	20	3.0	985	5.0	3,523	7.0	6,538
1.2	43	3.2	1,205	5.2	3,811	7.2	6,855
1.4	80	3.4	1,443	5.4	4,103	7.4	4,176
1.6	129	3.6	1,687	5.6	4,398	7.6	7,501
1.8	190	3.8	1,931	5.8	4,696	7.8	7,829
2.0	265	4.0	2,175	6.0	4,996	8.0	8,157
2.2	360	4.2	2,425	6.2	5,300	8.2	8,485
2.4	481	4.4	2,685	6.4	5,605	8.4	8,813
2.6	625	4.6	2,957	6.6	5,913		
2.8	791	4.8	3,238	6.8	6,224		

Estimated monthly discharge of Arkansas River at Pueblo, Colo.

[Drainage area, 4,600 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	417	265	343	21,090	0.075	0.086
February	2,425	158	1,070	59,425	.231	.241
March	310	190	258	15,863	.056	.065
April	310	190	234	13,924	.051	.057
May	1,443	265	876	53,863	.190	.219
June	791	225	543	32,311	.116	.129
July	1,382	60	277	17,032	.060	.069
August	8,321	60	613	37,692	.133	.153
September	360	225	271	16,126	.059	.066
October	360	265	311	19,123	.068	.078
November	417	265	307	18,268	.067	.075
December	360	287	333	20,475	.072	.083
The year	8,321	60	453	325,192	.098	1.321

ARKANSAS RIVER NEAR CANYON, COLO.

This station is located at the Hot Springs Hotel, 1½ miles west of Canyon and a short distance below the mouth of Grape Creek. Observations at this point were begun on April 17, 1889, the station being established here by Robert Robertson. The record has been maintained since that time, with occasional breaks due to absence or change of observer. The station is of special importance, being located at the mouth of the canyon and at a point practically above all of the irrigation ditches, except the Canyon City ditch (sometimes called the North Side ditch) and the South Canyon ditch (sometimes called the South Side ditch), both of which head above the station. During the irrigation season each of these ditches carries from 25 to 60 cubic feet of water per second, according to the needs of the irrigators, and their discharge should be added to the discharge at the station in order to obtain the total run-off at the mouth of the canyon. This site was used in 1888 for a gaging station by the State engineer of Colorado, and is highly favorable for obtaining accurate measurement. The channel of the river is straight for several hundred yards, both above and below, and the current, though swift, is not too great at high water nor too sluggish at low stages for satisfactory results. The banks on both sides are high and are not overflowed. The cross

section is regular and has not been subject to notable changes, except on the right bank, near the gage, where a sand bar has formed at times of low water.

The gage rod established by Mr. Robertson was of 2 by 6 inch timber, inclined, and attached to the crib of an old bridge on the south or right-hand side of the river, almost directly in front of the hotel. There were two bench marks: No. 1, on the top of a log of the crib; elevation, 10.01 feet above the datum; No. 2, in the cleft of a red bowlder at the foot of a charred stump 50 feet downstream and on the same side of the river; elevation, 9.60 feet. On April 13, 1891, the station was inspected by Frank Tweedy, and a third bench mark was established, this being a bedded rock 40 feet from the north end of the cable, toward Hot Springs Hotel and 10 feet from the river bank. It is marked "B. M. No. 3, U. S. G. S.," and is 15.98 feet above the zero of the gage. The present observer is Dr. J. L. Prentiss.

The measurements were at first made from a car suspended from a cable stretched across the river, the bridge from which measurements were originally made by the State engineer having been destroyed. Later a new suspension bridge was constructed in front of the hotel, necessitating the removal and replacement of the gage, and subsequent measurements were made from this bridge, which, having a clear span, offers no obstruction to the current. On October 4, 1895, it was found that the top of the gage had been broken off, necessitating its renewal for readings during high water. The channel was found to be filled with sand and gravel in front of the gage, requiring considerable work in order to make the water flow to the rod. It was decided, therefore, to put in a new gage where the stream could not deposit material. A point was chosen about 100 feet below the bridge, on the left bank, and a crib was built, anchored in place by rocks and bolts, the lower end of the gage being fastened to it. The upper end of the inclined portion was attached to a juniper tree. On December 27, 1895, the station was inspected, and it was found that readings had been made from the old rod, which, at the stage of water prevailing, recorded about 0.40 of a foot above the new rod on the opposite side of the river. When the water is high and extends with unbroken surface from bank to bank the readings are the same, but at low water the observations on the old rod are misleading, owing to the accumulation of sand and gravel in front of it.

On August 26, 1902, owing to the shifting of the channel a new rod, consisting of 4 by 4-inch timber, was placed in an inclined position on the north or left bank of the river at the site of the previous rod just below the north end of the suspension bridge. The rod on this date read practically the same as the old rod. The bench mark is the top point of a granite boulder embedded in the earth 60 feet east of the south end of the bridge, and about 10 feet from the south bank of the river. The zero of the rod is 16.055 feet below the bench mark.

The following discharge measurements were made during 1902 by J. E. Field and M. C. Hinderlider:

April 21: Gage height, 2.20 feet; discharge, 323 second-feet.
July 26: Gage height, 1.60 feet; discharge, 165 second-feet.
August 26: Gage height, 2.00 feet; discharge, 226 second-feet.

Daily gage height, in feet, of Arkansas River near Canyon, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.30	2.20	2.30	2.40	2.35	3.05	2.30	1.58	2.20	2.10	2.30	2.30
2	2.30	2.30	2.30	2.40	2.40	3.00	2.30	1.90	2.15	2.20	2.25	2.40
3	2.30	2.30	2.30	2.40	2.50	2.95	2.30	1.90	2.05	2.20	2.20	2.40
4	2.30	2.30	2.30	2.40	2.60	2.90	2.10	2.00	2.00	2.20	2.20	2.40
5	2.20	2.30	2.30	2.50	2.75	2.90	1.88	2.40	2.00	2.25	2.20	2.30
6	2.20	2.30	2.30	2.45	2.90	2.90	1.80	2.75	2.00	2.30	2.20	2.30
7	2.20	2.30	2.30	2.40	3.00	2.85	2.05	2.05	2.00	2.20	2.20	2.30
8	2.20	2.30	2.30	2.30	3.15	2.75	2.00	1.78	1.95	2.20	2.10	2.30
9	2.20	2.30	2.30	2.20	3.25	2.90	2.25	1.70	1.90	2.20	2.10	2.30
10	2.20	2.30	2.30	2.20	3.50	2.90	1.88	1.62	1.90	2.20	2.10	2.30
11	2.20	2.30	2.30	2.10	3.60	2.90	1.80	1.60	1.90	2.25	2.10	2.20
12	2.30	2.30	2.30	2.10	3.75	2.90	1.72	1.70	1.90	2.25	2.10	2.20
13	2.30	2.30	2.30	2.00	3.70	2.80	1.68	1.65	1.90	2.20	2.10	2.20
14	2.30	2.30	2.30	2.00	3.70	2.80	1.62	1.70	1.90	2.20	2.20	2.35
15	2.30	2.30	2.30	2.00	3.60	2.80	1.60	1.75	1.90	2.20	2.20	2.40
16	2.30	2.30	2.30	2.00	3.75	2.80	1.58	1.80	1.90	2.30	2.20	2.45
17	2.30	2.30	2.30	1.95	3.55	2.70	1.85	1.80	1.90	2.35	2.30	2.50
18	2.30	2.30	2.30	1.88	3.50	2.70	1.90	1.80	1.90	2.30	2.30	2.40
19	2.20	2.30	2.30	1.95	3.40	2.60	1.85	1.80	1.90	2.30	2.20	2.35
20	2.20	2.30	2.30	2.10	3.20	2.55	2.40	1.80	1.90	2.30	2.20	2.30
21	2.20	2.30	2.30	2.10	2.90	2.50	2.40	2.35	2.10	2.30	2.20	2.30
22	2.20	2.30	2.30	2.15	2.70	2.35	2.25	2.45	2.20	2.30	2.30	2.40
23	2.20	2.30	2.40	2.10	2.65	2.20	2.25	2.00	2.20	2.30	2.35	2.40
24	2.20	2.30	2.40	2.00	2.55	2.05	1.95	1.90	2.15	2.20	2.30	2.50
25	2.20	2.30	2.40	2.00	2.50	2.10	1.65	1.95	2.15	2.20	2.20	2.50
26	2.20	2.30	2.40	2.00	2.60	2.35	1.55	2.30	2.10	2.20	2.20	2.45
27	2.20	2.30	2.40	2.10	3.15	2.50	1.58	3.00	2.05	2.20	2.20	2.40
28	2.20	2.30	2.40	2.10	3.35	2.50	1.50	2.65	2.00	2.30	2.20	2.35
29	2.20	.....	2.40	2.20	3.00	2.45	1.42	2.40	2.00	2.25	2.20	2.20
30	2.20	.....	2.40	2.25	3.00	2.40	1.40	2.35	2.05	2.20	2.30	2.10
31	2.20	.....	2.40	.....	3.00	.....	1.40	2.25	.....	2.20	.....	2.15

Rating table for Arkansas River near Canyon, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	62	1.7	185	2.4	360	3.1	716
1.1	78	1.8	206	2.5	393	3.2	791
1.2	94	1.9	228	2.6	432	3.3	872
1.3	110	2.0	252	2.7	476	3.4	957
1.4	128	2.1	277	2.8	527	3.5	1,046
1.5	146	2.2	303	2.9	584	3.6	1,139
1.6	165	2.3	331	3.0	647	3.7	1,236

Estimated monthly discharge of Arkansas River near Canyon, Colo.

[Drainage area, 3,060 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	331	303	317	19,492	0.104	0.12
February	331	303	325	18,050	.106	.11
March	360	331	337	20,721	.110	.13
April	393	228	294	17,494	.096	.11
May	1,286	345	757	46,546	.250	.29
June	681	264	481	28,622	.157	.18
July	360	128	229	14,081	.075	.09
August	647	161	270	16,602	.090	.10
September	303	228	254	15,114	.083	.09
October	345	277	313	19,246	.102	.12
November	345	277	294	17,494	.100	.11
December	393	277	342	21,029	.112	.13
The year	1,286	128	351	254,491	.115	1.58

ARKANSAS RIVER AT SALIDA, COLO.

This station is located at the footbridge near the railroad shops at Salida, Colo. It was originally established by the Denver and Rio Grande Railroad April 11, 1895. The original gage rod was a vertical timber fastened to the north side of the footbridge. Considerable difficulty was experienced by its being knocked out by ice and by logs during high water, and a new inclined gage rod was put in place during the spring of 1901 by J. E. Field, consisting of a 6 by 6 inch oak timber fastened to the north trestle of the bridge, the graduations being extended by marks on the trestle above the timber. On July 31, 1901, the gage was lowered and set farther out into the stream.

Another gage was established at this station on August 27, 1902, the zero of which is 1.10 feet below the zero of the old gage. The gage heights from this date are taken on the new rod.

The measurements are all made from the suspension footbridge back of the Denver and Rio Grande Railroad.

The banks are high and do not overflow. The bed of the stream consists of sand, gravel, and boulders. Two large boulders interfere to a great extent with the accuracy of the results. As the station is an important one, these boulders should be removed, so as to improve the character of the channel, and thus render the results of measurements more reliable. The stream is very swift at this point, but the channel is straight, and the discharge can readily be measured from

the footbridge. Little water is used above Salida, and none is used below that place until Canyon is reached. The observer is William Furniss. The gage heights have been sent to the local forecast official of the Weather Bureau at Denver, who has had them published in the morning papers.

Discharge measurements of Arkansas River at Salida, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 11	J. E. Field	0.55	273
April 12	do	.55	286
May 5	do	1.40	706
May 19	do	1.80	1,144
May 12	M. C. Hinderlider	2.20	1,804
July 26	do	.30	224

Daily gage height, in feet, of Arkansas River at Salida, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	0.10	0.75	1.45	0.80	0.20	1.20	1.10
2	.10	.85	1.50	.70	.25	1.30	1.10
3	.10	.95	1.35	.55	.30	1.20	1.20
4	.10	1.10	1.30	.45	.30	1.05	1.20
5	.15	1.10	1.30	.40	.35	1.00	1.20
6	.25	1.30	1.30	.35	.40	1.00	1.20
7	.30	1.55	1.30	.30	.40	1.00	1.20
8	.30	1.60	1.30	.30	.30	1.00	1.20
9	.30	1.60	1.20	.25	.20	1.00	1.20
10	.25	1.70	1.20	.20	.20	1.00	1.20
11	.20	1.80	1.20	.20	.20	1.00	1.20
12	.20	1.85	1.20	.20	.20	1.00	1.20
13	.20	2.00	1.10	.20	.20	1.00	1.15
14	.20	2.05	1.10	.20	.10	1.00	1.10
15	.20	2.10	1.05	.20	.10	1.00	1.10
16	.10	2.10	1.00	.15	.10	1.00	1.00
17	.10	2.00	1.00	.10	.10	.90	1.00
18	.10	2.00	.90	.10	.10	.85	.95
19	.20	1.75	.75	.50	.15	.80	1.00
20	.35	1.55	.70	.60	.40	.80	1.05
21	.45	1.15	.70	.55	.60	.80	1.00
22	.35	.95	.65	.50	.55	1.15	1.00
23	.30	.90	.60	.40	.35	1.25	1.05
24	.30	.90	.55	.30	.30	1.20	1.10
25	.30	.95	.50	.25	.30	1.15	1.10
26	.35	1.20	.50	.15	.30	1.10	1.10
27	.45	1.50	.70	.10	[a] 1.30	1.05	1.05
28	.50	1.45	.70	.10	1.25	1.10	1.00
29	.50	1.45	.80	.10	1.20	1.10	.90
30	.60	1.60	.80	.10	1.20	1.10	.90
31	.....	1.40	.....	.20	1.20	.....	.90

[a] New rod placed on this date. Old rod read 0.2 foot; new rod read 1.30 feet. The heights from this time on are read from the new rod.

Rating table for Arkansas River at Salida, Colo., for 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
-0.3	140	.5	268	1.3	622	2.1	1,615
-.2	150	.6	293	1.4	702	2.2	1,799
-.1	162	.7	320	1.5	798	2.3	1,991
.0	175	.8	353	1.6	906	2.4	2,188
.1	190	.9	393	1.7	1,024	2.5	2,388
.2	206	1.0	441	1.8	1,150		
.3	224	1.1	494	1.9	1,287		
.4	245	1.2	554	2.0	1,442		

[a] This table is referred to the old gage. In using it 1.10 feet were subtracted from all gage heights after August 26.

Estimated monthly discharge of Arkansas River at Salida, Colo.

[Drainage area, 1,160 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	293	190	219	13,031	0.19	0.21
May	1,615	336	852	52,387	.73	.84
June	798	268	467	27,788	.40	.45
July	353	190	229	14,081	.20	.23
August	293	190	217	13,343	.19	.22
September	206	140	168	9,997	.14	.16
October	190	150	174	10,699	.15	.17

Miscellaneous measurements in the Arkansas River drainage basin for 1902.

[Made by W. P. Edwards.]

Date.	Stream.	Locality.	Discharge.
			Second-feet.
July 11	Trout Creek	Newell	4
July 12	Chalk Creek	Mount Princeton	17

RED RIVER DRAINAGE BASIN.

The headwaters of the Red River include several forks, all of which have their sources in northern Texas. Red River takes a general easterly direction along the northern boundary of Texas, and then turns toward the southeast and flows through a low, swampy region in Louisiana into the Mississippi, not far from the southern boundary of Mississippi. The Washita River rises in northern Texas, crosses southern Oklakoma, and flows into the Red River in the southern part of Indian Territory, about 10 miles from Denison, Tex.

The Sulphur Fork of the Red River has its headwaters in Hunt and Fannin counties, flows eastward, forming the boundary between Delta, Red River, and Bowie counties on the north, and Hopkins, Franklin, Titus, Morris, and Cass counties on the south, and empties into the Red River in Arkansas about 7 miles north of the boundary line between that State and Louisiana. The flow of this river is very unreliable, changing with the rainfall. If the summer is at all dry it ceases to flow altogether, but there always remains enough water standing in pools to water stock. During or immediately after protracted or unusually heavy rains, the river becomes very wide and deep, floods its bottoms, and often occasions considerable loss of stock and damage to planters and the railroads.

The Big Cypress River has its headwaters in Franklin and Titus counties, flows in a generally easterly direction, and empties into the Red River. The flow of the river is unreliable, varying with the rainfall. In the summer it ceases to flow, becoming dry, except in those places where the water stands in holes. After long or heavy rains the stream is liable to overflow its banks.

The Washita River at Anadarko is the only regular station in the Red River drainage basin.

WASHITA RIVER AT ANADARKO, OKLA.

This station, established October 25, 1902, by W. G. Russell, is located at the highway bridge, one-half mile north of the Anadarko railroad depot. The gage is of the usual wire type, with the scale-board graduated to feet and tenths, and spiked to the hand rail of the bridge. The initial point for sounding is on the right bank. The channel both above and below the station is straight for 200 feet; the right bank is high, and the left bank is low; both banks are liable to overflow; the bed of the stream is sandy and constant. The observer is James H. Dunlap, who reads the gage once each day.

The following discharge measurement was made in 1902:

October 25: Gage height, 2.50 feet; discharge, 171 second-feet.

Daily gage height, in feet, of Washita River at Anadarko, Okla.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.			
1		2.50	4.00	17		2.60	7.20
2		2.70	3.80	18		2.60	6.10
3		2.70	3.70	19		2.60	4.30
4		4.30	3.60	20		2.60	3.90
5		4.85	3.50	21		2.70	3.70
6		4.50	3.40	22		2.80	3.60
7		3.50	3.40	23		7.40	3.50
8		3.20	3.30	24		9.20	3.40
9		3.00	3.20	25		7.60	3.30
10		2.80	3.20	26	2.50	6.70	3.20
11		2.70	3.20	27	2.50	5.40	3.10
12		2.70	3.10	28	2.50	4.80	3.10
13		2.70	3.10	29	2.50	4.60	3.10
14		2.70	3.10	30	2.50	4.20	3.10
15		2.70	3.30	31	2.50		3.10
16		2.60	5.60				

Miscellaneous measurements in the Red River drainage basin.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
December 23	Sulphur Fork	St. Louis Southwestern Railroad bridge, near Naples, Tex.	[a] 3,097
December 24	Big Cypress	St. Louis Southwestern Railroad bridge, near Pittsburg, Tex.	[b] 101
November 17	Ouachita	Camden, Ark	2,477
November 15	Red	Garland, Ark	18,627

[a] Water 6 feet (approximately) above normal winter level.
[b] Water 2 feet (approximately) above normal winter level.

WESTERN GULF DRAINAGE.

Those stations from which the United States Geological Survey has obtained data during 1902, and which are located on rivers which drain into that portion of the Gulf of Mexico west of the Mississippi River, have been grouped into the following drainage basins: Sabine, Neches, Trinity, Brazos, Colorado (of Texas), Guadalupe, and Rio Grande.

SABINE RIVER DRAINAGE BASIN.

The Sabine River has its headwaters in Collin and Hunt counties, flows in a southeasterly direction to the State line, then south, forming the boundary between Texas and Louisiana, and empties into Sabine Lake, an arm of the Gulf, near Orange, Tex. When measured on

December 25, 1902, the river was swollen by the rains of the previous two months. At the time the measurement was taken the river was 150 feet wide and had a maximum depth of 19 feet, which was said, by those residing near by, to be about 3 feet above normal. The banks are steep and the river is deep in the whole cross section. The drainage area of the Sabine above Orange, Tex., is 10,400 square miles. The principal tributary of the Sabine is the Big Sandy River, which rises in the northern part of Wood County, flows southeast through Wood and Upshur counties, and empties into the Sabine River near the town of Big Sandy. The stream has a reliable flow throughout the entire year. Its flow as measured December 25, 1902, was considerably in excess of the least flow of the stream, because there had been a protracted rainy period before the measurement was taken. There were at one time three mills on this stream, all of which are now abandoned or destroyed. The Seagore mill was situated about 100 yards below the crossing of the county road where the measurement was made. A dam, made by driving piling and filling in with stone, was used to store the water and give a greater fall. The fall obtained was 6 feet. The plant fell into decay and was finally washed away by floods. Almost all traces of the mill are now gone. Three miles farther upstream is the Silas Smith mill site, and still farther upstream the Kay mill site. Each of these mills has shared the same fate.

Miscellaneous measurements in the Sabine drainage basin.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
December 25	Sabine River	At St. Louis Southwestern Railroad crossing.	1,150
Do	Big Sandy River	At county road crossing, 2 miles northeast of Big Sandy.	188

NECHES RIVER DRAINAGE BASIN.

The Neches River rises in Van Zandt County and flows through the heavily wooded section of east Texas and finally empties into Sabine Lake near Beaumont. Its drainage area above Beaumont is 10,200 square miles. Its largest tributary is the Angelina, but it receives many smaller streams in its course, and on account of its flowing through a timbered section the flow of these tributaries, although small, is reliable, and many of them support small water-power plants. These plants are located in Van Zandt, Henderson, Angelina, San Augustine, Houston, and Tyler counties and are to be taken up and described later in a special report by T. U. Taylor on "The Water

Power and Water Supply of Texas." When measured on September 10, 1902, the water was what is termed in east Texas clear water, but it had the leaf-stain color and gave a chromine color to white objects beneath the surface. Near Grapeland, in Houston County, the San Pedro has its head and almost at its inception has sufficient water to support the water-power plant of Ferguson & Weisinger, where a 12-foot overshot wheel operates a gristmill and cotton gin of 50 saws.

In its lower sections the Neches becomes more sluggish in its flow, has deep water, and partakes of the bayou characteristics nearer the Gulf. Near Beaumont the water from Lake Sabine sometimes impregnates it with salt water.

The principal tributary of the Neches is the Angelina, which rises in Smith County, flows in a southeastwardly direction, and empties into the Neches near Townbluff. It was measured December 27, 1902, after protracted rains, at the crossing of the Houston East and West Texas Railroad, about 9 miles north of Lufkin, Tex., by Edward C. H. Bantel. The flow at that time was considerably above the average. This is considered a reliable stream, and is said to never go dry at this point. It is subject to floods which inundate extensive bottom lands, and cause considerable damage.

Miscellaneous measurements in the Neches drainage.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
September 10	Neches	International and Great Northern Railroad bridge.	26
December 27	Angelina	North of Lufkin	1,361

TRINITY RIVER DRAINAGE BASIN.

The Trinity River rises in a network of small streams in the counties of Montague, Wise, and Parker, but their combined capacity at Dallas is not sufficient to keep the bottom or bed of the stream moist. The United States Geological Survey maintained a station at Dallas for a time, but it was abandoned on account of the small discharge. Below Dallas the Trinity flows through a wooded country, and consequently it is not subject to the sudden floods with their quick run-offs.

TRINITY RIVER AT RIVERSIDE, TEX.

The drainage area of the Trinity River above Riverside, Tex., is 16,000 square miles. A gaging station was established on the Trinity at Riverside, Tex., in December, 1902, by T. U. Taylor. The zero

of the gage is 66 feet below the top of the ties (or base of rail) in the north arm of the draw span of the International and Great Northern Railroad bridge. The elevation of the top of the pivot pier above gage datum is 56.5 feet, and that of the top of the channel of the lower chord of the arms of the draw span of the bridge is 62.9 feet. The gage consists of a tagged plumbers' chain to which is attached a lead weight in the form of a frustum of a cone. The bottom of the lead weight is marked 66, and every foot above this is marked with a brass tag giving its distance in feet above the bottom of the weight. The observer at Riverside is G. W. Higdon, who is in charge of the pumping plant of the International and Great Northern Railroad. In reading the gage it is only necessary to let the lead weight touch the water and then read off the distance the mark or point is from the upper end or zero mark of the chain.

The following measurements were made during 1902 on the Trinity and its tributaries:

September 10: At Riverside, gage height, 6 feet; discharge, 160 second-feet.
September 11: Near Oakwood, discharge, 120 second-feet.
September 11: Elkhart River, 4 miles northwest of Grapeland; discharge, 4 second-feet.

BRAZOS RIVER DRAINAGE BASIN.

This river has its source in the Staked Plains region of western Texas, and has a general southeasterly course, emptying into the Gulf of Mexico south of the mouth of Trinity River. Its drainage basin is entirely within the State of Texas.

Under the direction of Thomas U. Taylor the United States Geological Survey is maintaining stations in this basin at Waco and Richmond, Tex.

BRAZOS RIVER AT WACO, TEX.

On September 14, 1898, a gage was established on the southwest bank of Brazos River at Waco. It consists of an inclined iron bar, 3 inches by 1 inch, reading from 0 to 4.3 feet, bolted to a hard-pine stick 16 feet long, embedded in cement in the sloping limestone of the bank, flush with the surface, on which are painted the graduations above 4.3 feet. The gage is inclined to the horizontal at an angle whose sine is $\frac{5}{27}$. Three bench marks have been established. The first is on the lowest water table on the southwest pier of the suspension bridge, and is marked "U. S. G. S. 44.33 B. M." The hydrant at the corner of First and Austin streets is at an elevation (by gage) of 43.32 feet, while the top of the rail of the San Antonio and Aransas Pass Railroad a few feet from the hydrant is at an elevation of 41.12 feet. The bed of the river is shifting sand, and nearly every freshet modifies the cross section, so that at the same gage heights the river

sometimes flows in one and sometimes in two channels under the suspension bridge from which the measurements are made.

At high water the gage reading is obtained by measuring to the water surface from the top rail of the stiffening truss of the suspension bridge at a certain point when there is no load upon the bridge, and by taking this distance from 47.8 feet.

In the early part of 1902 a new camel-back truss bridge of one span was erected across the Brazos at Waco a few hundred feet above the suspension bridge. This new bridge crosses the river at an angle of 76 degrees. It has a footway on the east or downstream side that affords excellent facilities for measuring the flow of the stream, and there are no midstream piers to render measurements troublesome or doubtful. On the north pier of the new bridge a gage has been marked off to agree with the United States Geological Survey gage at the suspension bridge. The top of the cement floor of the new bridge at the southeast batter brace is at an elevation of 45.4 feet with respect to the United States Geological Survey gage. High-water gage heights can be read directly from the gage on the north pier, or the distance of the water surface can be measured from the cement floor and this subtracted from 45.4 feet will give the height of the river referred to the gage.

The Brazos reached in 1902 the lowest stage in its recorded history. In the latter part of 1901, from December 28 to 31, the gage reached the low mark of 2.3 feet, and several measurements were taken at this stage of the river to determine what was thought at that time to be the least discharge of the Brazos. An average discharge of 70 second-feet was then found. The river stood for seven days in January at this height and then fell to 2.2 feet, and then, in the latter part of January, it fell to 2.1 feet. During the first part of February the gage stood at 2.2 feet, but on the 19th of February again dropped to 2.1 feet. It remained at this height until March 7, when it dropped to 2 feet, the lowest mark since 1898, and the lowest mark ever reached on the gage. On March 8, 1902, the flow was measured by Thomas U. Taylor at a point 200 yards above the new bridge, at a section where the stream is only 24 feet wide. The average depth was 7 inches, and there was a mean velocity of 1.36 feet per second. This gave a discharge of 19 second-feet. This stage of the river continued until the afternoon of March 11.

Discharge measurements of Brazos River at Waco, Tex.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 14	C. N. Campbell	2.29	56
January 22	do	2.18	47
March 8	T. U. Taylor	1.98	20
July 25	do	21.00	70,500
July 30	do	16.00	26,700
July 31	do	14.00	20,800
August 1	do	11.80	13,800
August 5	do	6.70	4,200
September 5	do	4.90	1,730
September 6	do	4.30	1,230
December 17	do	3.71	892
December 20	do	3.68	863

Daily gage height, in feet, of Brazos River at Waco, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.30	2.20	2.10	4.60	2.75	5.90	4.40	11.65	3.20	4.85	2.55	5.80
2	2.30	2.20	2.10	4.60	2.70	7.00	4.15	9.25	3.15	5.55	2.50	7.65
3	2.30	2.20	2.10	4.20	2.60	8.60	3.70	8.25	3.10	6.10	3.55	6.45
4	2.30	2.20	2.10	3.90	2.60	7.50	3.50	7.20	4.40	6.10	3.70	6.20
5	2.30	2.20	2.10	3.60	2.80	8.75	4.05	6.70	4.55	6.90	3.30	6.20
6	2.30	2.20	2.10	3.40	3.00	7.40	5.30	6.40	4.40	5.85	8.80	5.60
7	2.30	2.20	2.05	3.85	3.20	6.20	5.50	6.20	5.55	5.20	7.60	5.00
8	2.20	2.20	2.00	3.50	3.40	5.75	4.75	5.75	5.20	4.80	7.10	4.80
9	2.20	2.20	2.00	4.60	4.90	5.30	4.30	5.35	4.60	4.75	5.90	4.75
10	2.20	2.20	2.00	4.40	7.50	4.95	3.95	5.05	6.70	4.50	5.70	4.65
11	2.20	2.30	2.20	4.00	6.95	4.55	3.50	4.85	7.20	4.30	5.30	4.50
12	2.20	2.30	3.70	3.85	5.95	4.45	3.40	4.65	6.00	4.00	5.30	4.40
13	2.20	2.30	3.75	5.25	5.45	4.35	3.75	4.50	5.35	3.75	5.35	4.40
14	2.20	2.20	3.20	4.90	5.15	4.10	3.80	4.40	5.10	3.60	7.70	4.35
15	2.20	2.20	4.80	3.90	5.65	3.85	5.10	4.40	4.90	3.40	5.70	4.30
16	2.20	2.20	7.00	3.65	5.75	3.70	5.10	4.30	4.75	3.30	7.80	3.80
17	2.20	2.20	5.80	5.00	4.90	3.90	5.90	4.20	4.55	3.20	10.30	3.65
18	2.10	2.20	5.35	4.00	4.40	4.10	4.65	3.85	4.30	3.10	8.80	3.70
19	2.10	2.15	5.20	4.10	8.95	3.70	4.60	3.70	4.00	3.10	5.95	3.70
20	2.10	2.10	5.10	3.90	12.15	3.50	4.60	4.30	3.85	3.00	5.80	3.60
21	2.10	2.10	5.05	3.60	7.75	3.35	4.75	4.05	3.75	3.10	9.35	3.60
22	2.20	2.10	4.50	4.15	7.25	3.30	7.05	3.75	3.70	3.85	7.05	3.50
23	2.20	2.10	4.45	3.90	8.50	3.30	11.40	3.70	3.65	3.45	6.70	3.50
24	2.20	2.10	3.95	3.65	10.80	3.40	11.60	3.70	3.45	3.60	6.40	3.50
25	2.10	2.10	3.80	3.50	10.45	3.15	15.50	3.60	3.40	3.60	14.75	3.50
26	2.20	2.10	3.55	3.40	9.75	3.10	32.10	3.55	3.35	3.50	8.65	3.50
27	2.20	2.10	3.45	4.25	8.35	4.90	31.35	3.35	3.45	3.15	6.80	3.50
28	2.20	2.10	3.80	3.40	8.05	5.10	27.05	3.30	6.15	3.05	6.20	3.50
29	2.20	.....	3.70	3.15	8.20	4.80	22.65	3.20	5.60	3.00	6.15	3.40
30	2.20	.....	5.00	3.10	7.70	4.80	17.30	3.20	5.05	3.00	6.05	3.40
31	2.20	.....	4.60	.....	6.90	.....	13.80	.....	.....	2.85	.....	3.40

Rating table for Brazos River at Waco, Tex., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	20	4.6	1,490	7.2	4,800	11.0	12,285
2.2	80	4.8	1,650	7.4	5,135	11.5	13,450
2.4	160	5.0	1,820	7.6	5,475	12.0	14,660
2.6	250	5.2	2,010	7.8	5,825	12.5	15,980
2.8	350	5.4	2,220	8.0	6,180	13.0	17,400
3.0	450	5.6	2,450	8.2	6,540	13.5	18,850
3.2	550	5.8	2,700	8.4	6,910	14.0	20,300
3.4	670	6.0	2,975	8.6	7,285	14.5	21,800
3.6	795	6.2	3,265	8.8	7,665	15.0	23,300
3.8	925	6.4	3,555	9.0	8,055	15.5	24,800
4.0	1,055	6.6	3,855	9.5	9,050	16.0	26,300
4.2	1,195	6.8	4,155	10.0	10,085	16.5	27,800
4.4	1,340	7.0	4,470	10.5	11,160	17.0	29,300

Estimated monthly discharge of Brazos River at Waco, Tex.

[Drainage area, 30,750 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
January	120	50	84	5,165	0.0027	0.003
February	120	50	74	4,110	.0024	.003
March	4,470	20	995	61,180	.0324	.037
April	2,062	500	1,062	63,193	.0345	.038
May	15,032	250	4,280	263,167	.1392	.160
June	7,570	500	2,123	126,327	.0690	.077
July	74,600	670	12,528	770,317	.4074	.470
August	13,810	550	2,354	144,742	.0766	.088
September	4,800	500	1,609	95,742	.0523	.058
October	4,310	375	1,230	75,630	.0400	.046
November	22,550	200	4,491	267,233	.1460	.163
December	5,562	670	1,494	91,862	.0486	.056
The year	74,600	20	2,694	1,968,668	.0876	1.199

BRAZOS RIVER AT RICHMOND, TEX.

The drainage area of the Brazos River above Richmond, Tex., is 44,000 square miles.

In the latter part of December, 1902, T. U. Taylor established a gaging station at Richmond, Tex., on the Brazos River. The gage consists of a tagged plumber's chain marked every foot with brass tags. The chain is 50 feet long, the bottom of the lead weight being the 50-foot mark. The zero of the gage is 50 feet below the top of the guard rail in the mid-span of the bridge of the Southern Pacific Railroad. The observer is W. B. Ransom, a local druggist, and observations were commenced on January 1, 1903.

Above and at Waco the river rises rapidly, and when it gets above the gage height of 30 feet overflows the bottom lands below the town. When the floods spread out over the bottom lands as they do from Waco to Richmond, the river stays up longer in its lower stretches than it does in the upper sections, as the the backwater in the bottoms and the lowlands serve as storage reservoirs and are drained slowly as the river recedes. At Hearne and below the river in 1899 was several miles in width. Its maximum height at Richmond occurred on July 7, 1899, when it stood 4 feet below the top of the guard rail, or at a gage height of 46 feet. The water was out over the bottoms above, and in Richmond it covered the tracks of the Southern Pacific Railroad.

The following measurements were made at Richmond in 1902:

August 2: Gage height, 28.1; discharge, 48,400 second-feet.
August 6: Gage height, 31.9; discharge, 60,470 second-feet.
August 19: Gage height, 7.1; discharge, 5,800 second-feet.

LITTLE RIVER AND ITS TRIBUTARIES.

The Sulphur Fork of the Lampasas rises in the town of Lampasas in two springs, the Hancock and the Hanna, with a joint flow as determined on August 18, 1902, by T. U. Taylor of 9 second-feet. Of this amount the Hancock had 7.6 second-feet and the Hanna 1.4. This is probably the least flow of the springs. These springs are fully described in Water Supply Paper No. 50, page 335. The Lampasas, the Salado, and the Leon unite southeast of Belton, in Bell County, at the "Three Forks," forming the Little River. The Salado rises in the village of Salado, 9 miles south of Belton, from springs that bear a striking resemblance to those of the Edwards formation. The measurement at Salado on December 19, 1902, can be regarded as the minimum flow, as there had been no rains for many months. The Salado has a reliable flow of 13 second-feet at its head and it is slightly reenforced lower down. At one time there were eleven different power plants in operation along this short stream, but at present there are

only three in active operation. Summer's mill, 2 miles above the "Three Forks," derives its power from a 10-foot dam. Dulaney's mill, 1 mile farther up the stream, derives its power from a dam 8 feet high, while Stinnett's flour mill, 6 miles farther up, gets an 18-foot head by means of a mill race 1 mile long. Below the "Three Forks" the river is known as Little River. It has two reliable streams in the Lampasas and Salado to feed it, and its flow is reliable, but probably on account of danger from overflows no attempts have been made to utilize its energy in power plants. Three irrigation plants have been located on the Little River within the last year in the neighborhood of Cameron.

San Gabriel River.—The San Gabriel River rises in Burnett County, and flows easterly through Williamson County, and joins Little River 10 miles north of Rockdale. Its waters are used for irrigation and power purposes near Georgetown and Taylor.

Miscellaneous measurements in Little River Basin.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
December 18	Salado	Dulaney's Mill	29
December 19	do	Salado	13
August 18	Sulphur Fork of Lampasas	Lampasas	9
February 15	San Gabriel	Jonah	34

COLORADO RIVER (OF TEXAS) DRAINAGE BASIN.

The Colorado River rises in the extreme western portion of the State, within a few miles of the eastern boundary of New Mexico, and flows in a general southeasterly direction, emptying into the Gulf of Mexico in Matagorda County. The drainage area above Austin is 37,000 square miles, and above Columbus it is 40,000 square miles, and it extends into the corner of New Mexico. Its main tributaries are the Concho, the San Saba, and the Llano. The Concho has a reliable flow above its junction with the Colorado, and if the stream below the junction were to receive its name from the one that contributed the most water the river below the junction would be known as the Concho instead of the Colorado. The Concho furnishes water for irrigation and water power, and supports in Irion and Tom Green counties some excellent irrigation systems, described in Water Supply Paper No. 71. The San Saba and the Llano rivers are described in the same paper.

The Colorado at Austin emerges from a canyon. From Austin to the Gulf it traverses a rather flat country, and its waters are utilized for many power plants, and during the season of 1902 60,000 acres of rice were sowed in the counties of Colorado, Wharton, and Matagorda, under canals that obtained their water from the Colorado.

Under the direction of Thomas U. Taylor, the United States Geological Survey is maintaining gaging stations in this basin at Columbus and Austin, Tex. During 1902 miscellaneous measurements were made by Mr. Taylor at several other places, as stated hereafter.

COLORADO RIVER AT COLUMBUS, TEX.

A gaging station was established at Columbus, Tex., on the Colorado River, in December, 1902. The zero of the gage is 50 feet below the top of the downstream pier on the west side of the river. A gage has been marked off by the county officers on this pier, but the observer for the United States Geological Survey uses a tagged chain, with lead weight for a sounder. The flood of 1900 was the highest known at Columbus, and it reached the gage height of 38.6 feet.

The following measurements were made on the Colorado at Columbus in 1902:

August 2: Gage height, 32.0 feet; discharge, 36,000 second-feet.
August 4: Gage height, 13.4 feet; discharge, 6,800 second-feet.
August 7: Gage height, 12.6 feet; discharge, 4,300 second-feet.
December 27: Gage height, 3.5 feet; discharge, 1,200 second-feet.

COLORADO RIVER AT AUSTIN, TEX.

Gage heights were first taken on the crest of the Austin dam on August 13, 1895, and were continued from that date until the failure of the dam occurred in April, 1900. The first discharge measurement was made on December 21, 1897. In February, 1899, the gage was placed on the Congress Avenue Bridge south of the city. This gage consists of a plain staff attached to a bath house. The observer is W. Peterson. The bench mark is on the first flange above the cribwork of the north pier of the highway bridge. Its height is 4.78 feet above the zero of the gage. Measurements of discharge are made in a narrow place in the river about one-fourth mile above this point. The flood of April 7, 1900, carried away the great masonry dam at Austin. This flood was general over southwest Texas, but its only disaster was limited to the demolition of that structure. A full discussion of this failure will be found in Water Supply Paper No. 40.

Prior to the flood of April 7, 1900, the discharge of the river at the station below the dam was at low stages absolutely under the control of the turbines at the power house at the dam; and measurements made opposite the city, at the station between the two bridges, did not give

the unobstructed flow of the river. Since the destruction of the dam, measurements have been made at the station a fourth of a mile above the highway bridge on Congress avenue.

Discharge measurements of Colorado River at Austin, Tex.

Date.	Hydrographer.	Gage height.	Discharge
1902.		*Feet.*	*Second-feet.*
January 20	C. N. Campbell	2.10	497
February 17	do	1.99	471
March 15	do	2.50	962
April 9	do	1.70	376
June 20	T. W. Taylor	1.40	252
June 21	do	1.32	186
Do	do	1.32	215
June 23	do	1.34	211
June 28	A. A. Cother	1.20	180
June 30	do	1.19	176
October 24	T. W. Taylor	1.55	293
October 25	do	1.50	282
October 28	A. A. Cother	1.45	286
October 30	do	1.40	293
November 4	do	4.10	3,600
November 5	do	3.20	1,717
November 6	do	2.60	1,216
November 11	do	2.40	1,100
November 17	do	6.80	13,917
November 18	do	6.20	11,650
November 21	do	3.10	1,686
November 22	do	8.40	20,083
November 24	do	9.80	26,246
November 25	do	7.40	16,613
November 27	do	6.50	12,845
December 2	do	4.00	2,783

Daily gage height, in feet, of Colorado River at Austin, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.85	1.90	1.83	1.90	1.95	3.25	2.85	10.10	1.55	2.50	1.40	3.15
2	1.85	1.90	1.80	2.00	1.85	5.15	2.25	8.60	1.60	2.40	1.40	3.70
3	1.85	1.90	1.80	1.90	1.75	4.00	4.60	5.80	1.60	4.35	1.50	4.85
4	1.85	1.95	1.75	1.80	1.85	3.45	5.60	4.50	1.90	5.00	4.15	4.35
5	1.85	2.00	1.70	1.73	1.95	2.90	4.05	4.00	3.45	4.05	3.10	3.70
6	1.85	2.00	1.70	1.73	1.85	2.75	3.15	3.55	3.80	3.65	2.70	3.30
7	1.85	1.95	1.70	1.70	1.95	2.45	2.75	3.20	3.00	3.45	3.25	3.05
8	1.85	1.98	1.70	2.05	1.95	2.35	2.50	3.05	3.45	2.90	3.30	2.95
9	1.90	2.00	1.70	1.75	3.20	2.20	2.35	3.00	3.50	2.55	2.85	2.75
10	1.90	2.00	1.70	1.70	3.70	2.15	2.20	3.05	5.30	2.35	2.55	2.65
11	1.90	2.00	1.80	1.60	3.25	2.05	2.15	2.60	4.15	2.20	2.40	2.60
12	1.90	2.00	1.80	1.53	2.90	2.00	1.95	2.50	3.45	2.10	2.30	2.50
13	1.95	2.00	4.00	3.10	2.65	1.85	1.80	2.55	3.15	1.95	2.35	2.50
14	1.95	1.90	3.10	4.15	2.45	1.70	2.65	2.70	2.85	1.90	3.15	2.42
15	1.95	2.00	2.60	5.10	2.35	1.60	2.35	2.55	2.06	1.80	2.45	2.35
16	1.98	2.00	2.05	6.15	2.20	1.60	2.20	2.40	2.45	1.75	2.15	2.30
17	2.00	1.95	3.20	4.85	2.15	1.63	2.25	2.20	2.35	1.70	4.70	2.25
18	2.00	1.95	2.90	4.20	2.15	1.60	2.05	2.10	2.20	1.70	5.30	2.25
19	2.00	1.95	2.70	3.30	5.25	1.50	3.15	2.00	2.10	1.60	4.15	2.00
20	2.10	1.90	2.50	3.15	8.05	1.43	2.40	2.00	2.05	1.60	3.30	2.00
21	2.10	1.90	2.38	2.95	8.85	1.40	2.25	1.90	2.00	1.60	3.00	2.15
22	2.00	1.90	2.30	2.75	5.95	1.38	2.10	1.92	1.90	1.60	5.75	2.10
23	2.00	1.90	2.23	2.60	4.35	1.35	2.15	1.82	2.35	1.55	9.85	2.10
24	2.00	1.88	2.20	2.50	3.90	1.30	2.25	1.72	2.70	1.55	10.90	2.05
25	1.95	1.85	2.10	2.40	3.40	1.30	5.70	1.70	2.40	1.50	7.40	2.00
26	1.93	1.85	2.15	2.33	3.15	1.30	9.10	1.70	3.05	1.45	8.15	1.95
27	1.90	1.85	2.00	2.30	2.95	1.30	11.10	1.67	2.95	1.45	6.75	1.95
28	1.90	1.85	1.93	2.20	3.10	1.20	11.85	1.65	2.80	1.42	4.90	1.90
29	1.90	.....	1.85	2.10	3.20	1.30	10.65	1.60	3.25	1.40	4.20	1.90
30	1.90	.....	1.80	2.00	3.00	2.05	10.35	1.60	2.90	1.40	3.55	1.90
31	1.90	.....	1.80	.....	2.85	.....	10.65	1.55	.....	1.40	.....	1.95

Rating table for Colorado River at Austin, Tex., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	180	3.6	2,480	6.0	10,850	8.4	20,450
1.4	240	3.8	2,890	6.2	11,650	8.6	21,250
1.6	320	4.0	3,340	6.4	12,450	8.8	22,050
1.8	410	4.2	3,865	6.6	13,250	9.0	22,850
2.0	520	4.4	4,490	6.8	14,050	9.2	23,650
2.2	650	4.6	5,250	7.0	14,850	9.4	24,450
2.4	820	4.8	6,050	7.2	15,650	9.6	25,250
2.6	1,020	5.0	6,850	7.4	16,450	9.8	26,050
2.8	1,240	5.2	7,650	7.6	17,250	10.0	26,850
3.0	1,490	5.4	8,450	7.8	18,050		
3.2	1,780	5.6	9,250	8.0	18,850		
3.4	2,110	5.8	10,050	8.2	19,650		

Estimated monthly discharge of Colorado River at Austin, Tex.

[Drainage area, 37,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	580	435	480	29,494	0.01	0.01
February	520	435	483	26,836	.01	.01
March	3,340	360	732	45,025	.02	.02
April	11,450	300	1,711	101,827	.05	.06
May	22,250	385	3,052	187,652	.08	.09
June	7,450	180	883	52,552	.02	.02
July	31,250	410	7,148	439,517	.19	.22
August	27,250	300	2,827	173,841	.08	.09
September	2,890	300	1,503	89,460	.04	.04
October	6,850	240	1,019	62,684	.03	.03
November	30,450	240	5,623	334,594	.15	.17
December	6,250	460	1,230	75,626	.03	.03
The year	31,250	180	2,224	1,619,108	.06	.79

Miscellaneous measurements on Colorado River.

Date.	Locality.	Discharge.
1902.		*Sec.-feet.*
June 19	Marble Falls	219
June 27	do	145
August 17	Ballinger	104

BARTON SPRINGS NEAR AUSTIN, TEX.

These springs are about 2 miles from the court-house at Austin. There are at present two distinct groups of springs that unite one-fourth mile below the stone bridge and form the main channel. The flow of these springs has responded to the rainfall on the Edwards Plateau with unfailing regularity. The Walsh spring on the south side of the stream which formerly ran a mill was dry for several years, but in 1900, a year of heavy rainfall, it revived and continued flowing for about a year, but during the whole of 1902 no water issued from this spring. The following measurements have been made of the flow of the springs:

Miscellaneous measurements of Barton Springs.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1894	C. C. Babb	17
1895	do	25
March, 1898	T. U. Taylor	20
May, 1898	do	30
August, 1900	do	69
December, 1900	do	33
June, 1902	do	19
August, 1902	do	19

LLANO RIVER, TEXAS.

The Llano River rises in Sutton County and flows east to its junction with the Colorado. Just below Junction City, in Kimble County, the North and South forks unite and form the main Llano.

The main Llano River is joined by the Johnson Fork of the Llano below Junction City. The water in this fork is almost exhausted, before it reaches the main Llano, by several small irrigation plants that derive their waters from it. The measurement of August 13, 1902, on the South Llano was stated by the mill owner and operator just south of the town to be at the lowest stage, and this is highly probable, as no rains of any account had fallen for some time. While the South Llano is much shorter than the North Llano, yet the North Llano on the same date was not flowing at their junction. The South Llano could easily supply sufficient water for an irrigation system of 6,000 acres, and the land that could be brought under ditch is rich and well placed for easy irrigation.

The capacity of the Llanos has not been developed to much extent either for power or irrigation purposes. Power plants are located at Junction City, 2 miles above the town of Llano, and at Llano. Its use for irrigation purposes is confined to the county of Kimble.

There are more individual irrigation plants in Kimble County fed by the Llano and its tributaries than in any other county in Texas, as can be seen by referring to Water Supply Paper 71. There are four water-power plants on the Llanos, but only three are in active operation at present. At Junction City, a dam about one foot high, constructed of logs and loose rocks, deflects part of the flow of the South Llano into a ditch whose bed is on the same level with that of the river. The ditch is 10 feet wide, 4 feet deep, and about 3 furlongs in length. The ditch follows the foothills to the fore bay or flume

100 feet long, 6 feet wide, and 6 feet deep. The power is developed by a 30-inch Leffel turbine, and is used to run a gristmill, a cotton gin of 70 saws, and to supply a tank 80 feet above the level of the water in the ditch. The tank is used as a part of the waterworks for the town of Junction. The water emerges from the turbine and flows back under the flume for about 60 feet, when it turns sharply to the east and is conducted back to the river. In addition to the power developed, there is a plan on foot to install an irrigation system of 6,000 acres. The main canal will be taken out of the river above Junction and will follow the foothills west of town and then cross the North Llano by an invert, and irrigate lands on the north side of the main Llano east of the town.

While there are many localities on the Llano between Junction and the town of Llano where power plants could be developed, yet no attempts have been made to construct additional plants except near the town of Llano. At Llano there are conditions for a good water-power plant. Just north of the town a small plant is at present used in running the waterworks, the electric-light plant, and the flour mill. The dam is constructed partly of stone and partly of wood. It is built on a turtleback formation of granite that would afford an excellent foundation for a masonry dam. All the necessary factors for a successful power plant—the foundation, the water, the finest stone in the world, and good railroad facilities—are here in abundance and only await capital.

Miscellaneous measurements on the Llano and its tributaries.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
June 26	Llano	Above Llano	55
August 13	Johnson Fork	1 mile above Segovia	11
Do	South Llano	One-fourth mile below Junction City.	94
August 14	Bear Creek	Morales farm	3

SAN SABA RIVER, TEXAS.

The San Saba River rises in two springs near Fort McKavett, in the western part of Menard County, and flows in an easterly direction for over 100 miles to its junction with the Colorado. Between Fort McKavett and Menardville the river is fed by many springs, some of which are utilized in small irrigation systems before their waters join those of the San Saba. The largest of these springs is known as the

Wilkinson spring, and is situated above Menardville, on the farm of W. J. Wilkinson. It forms the headwaters of Clear Creek. This stream is only about 3 miles long. Its waters are only partially utilized for irrigation purposes, but it would easily irrigate 1,500 to 2,000 acres. A resident of thirty years states that the flow of this stream is greater in the summer than in the winter. However, the variation is rather slight, so that its capacity for irrigation or power purposes would not be subject to large fluctuations.

Four miles above Menardville the Noyes ditch, 9 miles long, is taken out of the San Saba and deflects most of the normal flow. This ditch feeds an irrigation system both above and below the town of Menardville. Above Menardville the water of the San Saba is used for the irrigation systems of Byers and Striegler and for the Noyes system, which lies above and below Menardville. The Sieker and the Kitchen ditches, 2 and 5 miles, respectively, below Menardville, are taken from the San Saba. For a full description of these irrigation systems see Water Supply Paper No. 71.

Twelve miles below Menardville the river enters the canyons, which it traverses for 50 miles. The canyons finally widen into rich valleys at a point known as "The Narrows," 17 miles above the town of San Saba, opposite the ranch of Hilliard Doran. The measurement made on June 24 can be relied upon as the least flow of the San Saba, as no rain of any consequence had fallen on its drainage area for nearly two years. While the flow at Fort McKavett is more than this, and while Clear Creek and the smaller streams swell this flow above Menardville to double this amount, the irrigation systems in Menard County practically take all the water out of the river. When this measurement of 25 second-feet was made at "The Narrows" the river was reported as not flowing above the mouth of Brady Creek. Twelve miles above San Saba the Sloan spring emerges from the foothills of the Edwards plateau. It has a capacity of 9 second-feet, and its waters are utilized in one of the most effective irrigation systems in Texas.

So far the waters of the San Saba have not been used for power purposes on the main stream, but in its course there are many excellent sites for dams that would make practical use of the waste potential energy.

Miscellaneous measurements on the San Saba and its tributaries.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-feet.*
August 14	San Saba	1 mile below Fort McKavett.	26
Do	Clear Creek	9 miles above Menardville.	25
August 15	San Saba	North of Menardville court-house.	8
Do	Noyes Ditch	Near M. E. Church, Menardville.	23
June 24	San Saba	Doran's ranch	25
June 25	do	1 mile below Doran's ranch.	28
Do	do	Barnetts Ford, above San Saba.	28
June 24	Mill Creek	San Saba	8

GUADALUPE RIVER DRAINAGE BASIN.

The Guadalupe River rises in the southern central part of Texas, flows southeast, and empties into San Antonio Bay. During the summer of 1902 its discharge was the least in its observed history, causing much loss above New Braunfels, where half a dozen power plants were forced to shut down or to run on short time. The flow at this time was so low that special efforts were made to obtain measurements at several points along its course. The results of these measurements are shown in the accompanying table.

Under the direction of Thomas U. Taylor, the U. S. Geological Survey is maintaining a station in this basin near Cuero, Tex.

GUADALUPE RIVER NEAR CUERO, TEX.

This station was established by Thomas U. Taylor December 26, 1902. It is located at the dam of Carl Buchel's power house, 3 miles north of Cuero, Tex. The gage is a plain staff graduated to feet and tenths. It is mounted on the wall of the power house near the dam, and is read twice daily by Carl Buchel. The initial point for sounding is on the left bank. The channel is straight for about one-fourth of a mile above and 400 feet below the station. The right bank is low and liable to overflow; the left bank is high and rocky. The bed of the stream is of clay. The bench mark is on the crest of the dam. Its elevation is the same as the zero of the gage.

The Guadalupe, while the best water-power stream in Texas, has a drainage area above Cuero of only 5,100 square miles. Its efficiency is due almost entirely to the canal at New Braunfels. Below New Braunfels the largest tributary is the San Marcos River.

Miscellaneous measurements in the Guadalupe River drainage basin.

Date.	Stream.	Station.	Discharge.
1902.			*Sec.-feet.*
August 29	Gaudalupe	Comfort	7
August 28	do	Near Walhalla	11
Do	do	6 miles above New Braunfels.	9
August 26	do	North of New Braunfels, near cemetery crossing.	13
August 27	do	One-fourth mile above International and Great Northern R. R. bridge.	342
August 30	do	Below Erskine Falls	355
February 22	Comal	Landa Mill Race and Comal Spring Creek.	333
August 26	do	do	318
August 12	Johnsons Fork	On Kerrville and Junction City road crossing.	9
February 22	San Marcos	Prairie Lea	149
September 9	do	Westerfield Ford	150
March 12	San Antonio	San Antonio	7
October 21	do	Hot Wells	34

RIO GRANDE DRAINAGE BASIN.

The Rio Grande rises in southern Colorado, in the Rocky Mountains, flows south through New Mexico and thence southeast, forming the boundary between Texas and Mexico. Pecos River, which rises in northern New Mexico and flows south across eastern New Mexico and western Texas, is its principal tributary from the north. The Conchos River is its principal tributary from the Mexican side. The determination of the amount of water in the Rio Grande is of importance, both on account of its use in irrigation and from its bearing upon interstate and international distribution of water. The New Mexico and Texas stations are maintained by the International (Water) Boundary Commission, and the data are furnished by W. W. Follett, consulting engineer for the Commission. On account of the shifting character of the river beds at the international (water) boundary stations, no rating tables have been prepared. The estimated monthly discharges are from daily discharges, computed directly from the discharge measurements. The following list includes the stations in the Rio Grande drainage basin:

Rio Grande at Eagle Pass, Tex.
Las Moras Creek.
San Felipe Creek.
Rio Grande below mouth of Devils River, Texas.
Devils River at Devilsriver, Tex.

Pecos River at Moorhead, Tex.
Pecos River, Margueretta flume, and West Valley ditch, near Pecos, Tex.
Rio Grande at Langtry, Tex.
Rio Grande below Presidio, Tex.
Rio Grande above Presidio, Tex.
Rio Grande near Fort Hancock, Tex.
Rio Grande near El Paso, Tex.
Rio Grande near San Marcial, N. Mex.
Rio Grande at water tank; Buckman, near Rio Grande, N. Mex.
Rio Grande at Embudo, N. Mex.
Rio Grande near Cenicero, Colo.
Rio Grande near Del Norte, Colo.

RIO GRANDE AT EAGLE PASS, TEX.

This station was established in April, 1900, by the International (Water) Boundary Commission. It is a half mile above the highway bridge between Eagle Pass and Ciudad Porfirio Diaz, Mexico, and about 540 miles below El Paso, Tex. During 1902 the following measurements of discharge were made by O. B. Powell, D. Griggs, and R. F. Dowe:

Discharge measurements of the Rio Grande at Eagle Pass, Tex.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 3	2.3	2,041	March 29	1.8	1,495
January 7	2.3	1,945	April 1	1.7	1,437
January 10	2.5	2,253	April 4	1.7	1,314
January 13	2.5	2,304	April 8	1.7	1,270
January 17	2.4	2,152	April 12	1.7	1,347
January 25	2.2	1,888	April 15	2.75	2,976
January 28	2.2	1,848	April 19	2.0	1,633
January 31	2.2	1,828	April 23	1.7	1,377
February 4	2.2	1,965	April 26	1.7	1,325
February 8	2.2	2,017	April 29	1.7	1,319
February 11	2.2	2,054	May 3	1.6	1,261
February 15	2.2	1,957	May 5	4.65	8,742
February 18	2.2	2,034	May 10	2.2	1,624
February 22	2.1	1,916	May 13	2.0	1,849
February 25	2.1	1,954	May 17	1.9	1,428
March 1	2.0	1,901	May 19	8.0	[a] 34,300
March 8	1.9	1,826	May 21	2.95	2,609
March 11	1.9	1,600	May 23	2.3	2,118
March 15	1.9	1,550	May 26	2.1	1,959
March 18	1.8	1,478	May 30	1.9	1,707
March 22	1.8	1,415	June 3	2.0	1,721
March 25	1.8	1,431	June 7	1.8	1,498

[a] Partly estimated.

Discharge measurements of the Rio Grande at Eagle Pass, Tex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
June 10	1.7	1,326	September 26	3.15	4,423
June 14	2.2	1,960	September 29	2.9	3,890
June 17	1.9	1,517	October 1	2.9	3,826
June 21	2.2	2,207	October 3	3.05	4,183
June 24	2.0	1,544	October 6	3.5	5,157
June 28	1.9	1,462	October 8	2.9	3,743
July 1	1.8	1,369	October 10	2.6	3,130
July 2	3.7	4,248	October 13	3.0	4,085
July 7	1.8	1,360	October 15	2.9	3,356
July 10	2.0	1,592	October 17	2.6	3,019
July 12	2.9	3,027	October 20	2.5	2,460
July 15	4.75	7,906	October 22	2.4	2,335
July 17	3.6	4,122	October 25	2.3	2,270
July 19	3.3	3,552	October 27	2.3	2,263
July 22	3.55	4,495	October 29	2.2	2,078
July 24	4.5	7,404	October 31	2.2	2,084
July 26	7.5	[a] 22,980	November 3	2.8	3,175
July 28	6.4	16,676	November 5	2.5	2,671
July 30	6.4	17,283	November 7	3.0	3,920
August 2	4.85	9,819	November 10	2.4	2,428
August 4	4.3	7,741	November 12	2.2	2,279
August 7	3.5	4,987	November 14	2.1	2,086
August 9	3.55	5,210	November 17	2.1	1,969
August 11	3.0	3,915	November 19	2.1	1,963
August 15	5.2	9,600	November 21	2.55	2,632
August 19	4.1	6,050	November 23	2.1	2,035
August 21	3.9	5,574	November 26	2.1	2,056
August 23	3.9	5,523	December 4	2.1	2,257
August 26	4.4	7,388	December 6	2.1	2,354
August 28	4.7	8,305	December 9	2.2	2,542
August 30	4.0	6,166	December 11	2.2	2,582
September 2	5.9	14,448	December 13	2.2	2,559
September 4	5.0	8,649	December 16	2.2	2,572
September 9	7.05	25,740	December 18	2.1	2,420
September 10	8.7	30,902	December 20	2.2	2,557
September 13	7.7	25,612	December 23	2.2	2,494
September 18	4.6	8,884	December 26	2.1	2,419
September 20	4.1	8,046	December 29	2.1	2,402
September 22	4.85	10,644	December 31	2.1	2,398
September 24	3.5	5,542			

[a] Partly estimated.

Daily gage height, in feet, of the Rio Grande at Eagle Pass, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.30	2.20	2.00	1.70	1.70	2.15	1.80	5.35	5.25	2.90	2.20	4.50
2	2.30	2.20	2.00	1.70	1.70	2.10	3.65	4.90	5.75	3.00	2.65	3.80
3	2.30	2.20	2.00	1.70	1.60	2.05	2.35	4.55	5.10	3.10	2.80	2.35
4	2.30	2.20	2.00	1.70	3.95	1.95	1.95	4.25	4.95	3.20	2.55	2.10
5	2.30	2.20	1.90	1.70	4.70	1.90	1.85	4.20	5.30	3.00	2.50	2.10
6	2.30	2.20	1.90	1.70	3.15	1.80	1.80	3.90	5.90	3.40	2.65	2.10
7	2.30	2.20	1.90	1.70	2.75	1.80	1.75	3.55	5.90	3.15	2.95	2.75
8	2.30	2.20	1.90	1.70	2.45	1.80	1.70	3.80	6.25	2.85	2.75	3.40
9	2.45	2.20	1.90	1.70	2.35	1.75	1.95	3.70	7.25	2.65	2.55	2.25
10	2.50	2.20	1.90	1.70	2.15	1.70	1.95	3.35	8.60	2.55	2.40	2.20
11	2.50	2.20	1.90	1.70	2.00	1.70	2.30	3.05	8.90	2.45	2.30	2.20
12	2.50	2.20	1.90	1.70	2.00	1.70	2.90	3.00	8.00	2.50	2.20	2.20
13	2.50	2.20	1.90	1.70	2.00	1.90	2.75	2.95	7.60	3.00	2.20	2.20
14	2.50	2.20	1.90	1.85	2.00	2.25	4.45	3.20	6.95	2.90	2.10	2.20
15	2.50	2.20	1.90	2.40	1.90	2.05	4.60	5.15	6.00	2.85	2.10	2.20
16	2.45	2.20	1.90	2.45	1.90	2.00	3.80	4.35	5.35	2.75	2.15	2.20
17	2.40	2.20	1.80	2.15	1.90	1.90	3.55	4.05	4.90	2.65	2.20	2.20
18	2.40	2.20	1.80	2.00	4.45	2.20	3.30	3.95	4.60	2.55	2.10	2.10
19	2.40	2.20	1.80	2.00	7.35	2.00	3.30	4.10	4.40	2.50	2.10	2.15
20	2.30	2.20	1.80	1.85	3.75	1.90	3.30	4.10	4.00	2.50	2.10	2.20
21	2.30	2.10	1.80	1.80	2.75	2.20	3.20	3.85	3.85	2.50	2.40	2.20
22	2.30	2.10	1.80	1.80	2.35	2.30	3.35	3.65	4.85	2.45	2.10	2.20
23	2.30	2.10	1.80	1.75	2.30	2.25	3.30	3.85	4.35	2.40	2.10	2.15
24	2.30	2.10	1.80	1.70	2.25	2.00	4.05	3.75	3.50	2.40	2.10	2.15
25	2.20	2.10	1.80	1.70	2.20	1.90	5.00	3.90	3.30	2.30	2.25	2.20
26	2.20	2.10	1.80	1.70	2.10	1.90	7.40	4.25	3.15	2.30	2.20	2.15
27	2.20	2.10	1.80	1.70	2.10	2.00	6.45	4.85	2.95	2.30	2.00	2.10
28	2.20	2.00	1.90	1.70	2.00	1.90	6.30	4.65	2.90	2.30	2.20	2.10
29	2.20	.....	1.80	1.70	1.95	1.85	6.40	4.25	2.90	2.20	2.15	2.10
30	2.20	.....	1.80	1.70	1.90	1.80	6.35	4.00	2.90	2.20	2.15	2.10
31	2.20	.....	1.80	.....	2.30	.....	5.80	4.55	.....	2.20	.....	2.10

Estimated monthly discharge of the Rio Grande at Eagle Pass, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
January	2,300	1,830	2,052	126,189
February	2,050	1,830	1,973	109,587
March	1,900	1,420	1,606	98,737
April	2,260	1,270	1,448	86,182
May	29,200	1,260	3,382	207,967
June	2,330	1,330	1,648	98,063
July	22,400	1,270	6,094	374,717
August	12,140	3,800	6,539	402,070
September	32,000	3,890	12,868	765,719
October	4,920	2,080	3,070	188,787
November	3,800	1,930	2,385	141,937
December	8,400	2,260	2,904	178,582
The year	32,000	1,260	3,831	2,778,487

LAS MORAS CREEK, TEXAS.

Las Moras Creek, which rises in the town of Brackettville, Kinney County, Tex., and empties into the Rio Grande about 25 miles above Eagle Pass, has had a variable record since measurements have been made upon it. In December, 1895, C. C. Babb found a total discharge of 21 second-feet. In June, 1898, the "Brackett flood" occurred, as described in Water-Supply Paper No. 50, page 344, and Las Moras showed an increased flow up to the latter part of 1901. The flow was measured by T. U. Taylor in June, 1899, when it had a discharge of 60 second-feet at Mulligan's bend, one-fourth mile below the courthouse; in ———, 1900, when a flow of 51 second-feet was found at the same section; in December, 1901, when a flow of —— second-feet was obtained, and in 1902 two checked measurements on September 2 and 3 each gave a discharge of only 11 second-feet.

SAN FELIPE CREEK, TEXAS.

San Felipe Creek has its source in four large springs. These springs are all above the Southern Pacific Railroad bridge, 1 mile east of Del Rio, at distances from 200 yards to 2 miles. Measurements have been made on the San Felipe since December, 1895, when C. C. Babb found a joint discharge on the creek and of Madre ditch (which includes the total flow of the springs) to be 99 second-feet. The following measurements have since been made by and under the direction of T. U. Taylor: In June, 1899, a joint flow of 84 second-feet; September, 1900, a joint flow of 149 second-feet; in December, 1901, a flow of 150 second-feet, and in September, 1902, a flow of 115 second-feet were obtained. The variation in the flow is caused by an increased rainfall in the Edwards Plateau to the north of Del Rio. An increased flow is found in all of the outlets of the underground waters of the plateau which stretches from the Southern Pacific Railroad north to the Texas Pacific Railroad. The crest of increased flow follows the increased rainfall in the highlands to the north.

RIO GRANDE BELOW MOUTH OF DEVILS RIVER, TEXAS.

This station was established in April, 1900, by the International (Water) Boundary Commission. It is alongside the Southern Pacific Railway track, about a half mile below the mouth of Devils River and about 480 miles below El Paso.

Discharge measurements of the Rio Grande near Devilsriver, Tex.

[Made by James P. Hague, J. D. Dillard, and A. L. Wilcox.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 6	3.5	2,152	July 8	3.55	1,765
January 10	3.9	2,944	July 12	4.3	3,204
January 14	3.8	2,591	July 15	5.75	6,495
January 19	3.7	2,147	July 20	4.7	3,875
January 23	3.5	2,107	July 24	6.8	9,735
January 26	3.5	1,955	July 29	9.1	15,560
January 30	3.5	1,865	August 2	6.5	8,779
February 5	3.5	1,943	August 6	5.3	4,998
February 10	3.5	2,034	August 11	4.85	4,106
February 13	3.5	2,048	August 15	6.85	10,000
February 17	3.5	2,071	August 19	5.6	6,038
February 20	8.5	2,172	August 23	5.7	6,357
February 24	3.5	2,037	August 28	6.3	8,205
March 2	3.4	1,826	September 1	7.15	10,467
March 5	3.3	1,697	September 5	8.7	14,587
March 9	3.3	1,592	September 9	11.75	29,431
March 12	3.3	1,716	September 13	9.65	19,549
March 16	3.3	1,672	September 17	6.35	10,064
March 20	3.2	1,579	September 19	6.1	8,864
March 24	3.25	1,622	September 23	5.35	5,602
March 28	3.1	1,496	September 27	4.85	4,133
April 3	3.1	1,438	October 2	4.7	3,748
April 8	3.1	1,405	October 6	5.0	4,497
April 11	3.1	1,379	October 10	4.4	2,889
April 14	4.6	4,393	October 14	4.65	3,393
April 19	3.25	1,488	October 18	4.35	2,856
April 26	3.1	1,253	October 22	4.2	2,491
May 1	3.1	1,243	October 25	4.15	2,451
May 6	3.4	1,671	October 30	4.05	2,226
May 10	3.2	1,379	November 2	4.75	3,795
May 16	3.3	1,558	November 6	4.85	3,847
May 20	3.95	2,654	November 10	4.1	2,353
May 24	3.4	1,600	November 14	3.95	2,117
May 29	3.3	1,426	November 18	3.9	2,025
June 3	3.4	1,620	November 22	3.9	2,027
June 7	3.3	1,398	November 26	3.9	2,095
June 11	3.3	1,471	December 2	3.9	2,052
June 15	3.5	1,807	December 8	4.0	2,168
June 19	3.4	1,662	December 13	3.95	2,112
June 24	3.35	1,556	December 18	3.9	2,074
June 28	3.4	1,502	December 23	3.9	2,051
July 3	3.4	1,497	December 30	3.9	2,041

Daily gage height, in feet, of the Rio Grande near Devilsriver, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.60	3.50	3.50	3.10	3.10	3.80	6.25	6.85	7.35	4.70	4.35	3.90
2	3.60	3.50	3.40	3.10	3.10	3.50	3.75	6.45	7.25	4.70	4.60	3.90
3	3.60	3.50	3.50	3.10	3.10	3.40	3.40	6.20	7.25	5.10	4.35	3.85
4	3.60	3.50	3.45	3.10	4.80	3.40	3.35	5.95	7.30	4.80	4.35	3.80
5	3.55	3.50	3.30	3.10	3.75	3.30	3.30	5.65	8.65	5.00	4.30	3.95
6	3.50	3.50	3.30	3.10	3.55	3.30	3.30	5.25	8.00	4.95	4.85	4.05
7	3.50	3.50	3.30	3.10	3.60	3.30	3.30	5.90	8.60	4.65	4.55	4.05
8	3.50	3.50	3.30	3.10	3.35	3.30	3.50	5.50	9.70	4.45	4.35	4.00
9	3.90	3.50	3.30	3.10	3.20	3.30	3.40	4.95	11.65	4.40	4.20	3.90
10	3.85	3.50	3.30	3.10	3.20	3.30	4.05	4.75	12.75	4.40	4.10	4.00
11	3.80	3.50	3.30	3.10	3.10	3.35	4.40	4.70	10.90	4.35	4.05	4.00
12	3.80	3.50	3.30	3.10	3.10	3.60	4.20	4.60	10.40	4.75	4.00	4.00
13	3.80	3.50	3.30	3.40	3.10	3.75	5.35	4.50	9.50	4.75	3.90	3.90
14	3.80	3.50	3.30	4.10	3.10	3.65	6.60	7.50	8.45	4.65	3.90	3.90
15	3.70	3.50	3.30	3.70	3.10	3.50	5.60	6.85	7.30	4.55	3.90	3.90
16	3.70	3.50	3.30	3.50	3.20	3.50	5.15	6.00	6.65	4.45	3.90	3.90
17	3.70	3.50	3.30	3.40	3.20	3.50	4.80	6.00	6.35	4.40	3.90	3.90
18	3.70	3.50	3.30	3.40	10.00	3.50	4.85	5.95	6.05	4.35	3.90	3.90
19	3.70	3.50	3.20	3.30	5.60	3.40	4.75	5.60	5.95	4.30	3.90	3.95
20	3.60	3.50	3.20	3.15	3.95	3.90	4.70	5.85	5.50	4.30	3.90	3.90
21	3.60	3.50	3.20	3.10	3.75	3.95	4.95	5.65	6.10	4.20	3.90	3.90
22	3.60	3.50	3.20	3.10	3.45	3.80	4.85	5.65	6.55	4.20	3.90	3.90
23	3.50	3.50	3.20	3.10	3.40	3.50	5.65	5.70	5.30	4.15	3.95	3.90
24	3.50	3.50	3.25	3.10	3.40	3.40	6.50	5.60	5.00	4.10	4.20	3.90
25	3.50	3.50	3.20	3.10	3.65	3.40	10.15	5.95	4.80	4.10	3.95	3.90
26	3.50	3.50	3.10	3.10	3.50	3.40	9.55	6.75	4.90	4.00	3.90	3.90
27	3.50	3.50	3.10	3.10	3.40	3.40	8.00	6.95	4.85	4.05	4.05	3.90
28	3.50	3.50	3.10	3.10	3.40	3.40	8.40	6.20	4.70	4.10	3.90	3.90
29	3.50	.....	3.10	3.10	3.30	3.35	9.20	5.90	4.70	4.10	3.90	3.90
30	3.50	.....	3.10	3.10	4.20	3.30	8.05	6.30	4.70	4.10	3.90	3.90
31	3.50	.....	3.10	.....	4.20	.....	7.55	7.25	.....	4.10	.....	3.90

Estimated monthly discharge of the Rio Grande near Devilsriver, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	2,940	1,860	2,246	138,129
February	2,170	1,880	2,022	112,304
March	1,940	1,500	1,646	101,217
April	3,270	1,250	1,535	91,359
May	23,000	1,240	2,656	163,339
June	2,650	1,400	1,755	104,450
July	18,700	1,360	6,372	391,795
August	12,200	3,460	7,071	434,797
September	35,500	3,700	12,122	721,329
October	4,770	2,150	3,037	186,744
November	3,850	2,030	2,400	142,790
December	2,250	1,930	2,080	127,914
The year	35,500	1,240	3,745	2,716,167

DEVILS RIVER AT DEVILSRIVER, TEX.

This station was established in April, 1900, by the International (Water) Boundary Commission. It is opposite the Southern Pacific Railway station at Devilsriver. The river is about 50 miles in length, has a perennial flow, and during flood periods is subject to great fluctuations.

Discharge measurements of Devils River at Devilsriver, Tex.

[Made by James P. Hague, J. D. Dillard, and A. L. Wilcox.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 5	2.0	497	July 2	2.0	425
January 11	2.1	488	July 11	2.0	431
January 18	2.0	495	July 19	2.0	418
January 22	2.0	489	July 28	2.1	466
January 29	2.0	472	August 5	2.0	415
February 6	2.0	490	August 14	2.0	431
February 9	2.0	453	August 20	2.0	408
February 16	2.0	474	August 28	2.0	406
February 23	2.0	505	September 4	2.25	543
March 1	2.0	497	September 12	2.2	447
March 8	2.0	503	September 16	2.2	445
March 17	2.0	493	September 18	2.2	428
March 23	2.0	490	September 26	2.15	492
March 29	2.0	486	October 5	2.15	443
April 4	2.0	479	October 13	2.15	435
April 8	2.0	475	October 21	2.1	421
April 15	2.0	487	October 29	2.1	419
April 25	1.9	438	November 5	2.15	429
May 5	2.3	656	November 13	2.15	432
May 9	2.0	446	November 22	2.15	414
May 19	4.0	2,479	November 26	2.1	392
May 23	2.4	742	December 2	2.25	499
May 28	2.2	582	December 8	2.15	428
June 2	2.2	536	December 13	2.1	402
June 14	2.1	483	December 18	2.1	415
June 23	2.05	470	December 23	2.05	389
June 27	2.0	448	December 30	2.05	386

Daily gage height, in feet, of Devils River at Devilsriver, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.00	2.00	2.00	2.00	1.90	2.20	2.00	2.00	2.00	2.10	2.10	2.20
2	2.00	2.00	2.00	2.00	1.90	2.20	2.00	2.00	2.00	2.20	2.40	2.30
3	2.00	2.00	2.00	2.00	1.90	2.20	2.00	2.00	2.00	2.35	2.35	2.20
4	2.00	2.00	2.00	2.00	3.00	2.20	2.00	2.00	2.25	2.25	2.25	2.15
5	2.00	2.00	2.00	2.00	2.40	2.20	2.00	2.00	2.05	2.15	2.15	2.15
6	2.00	2.00	2.00	2.00	2.20	2.20	2.00	2.00	2.00	2.15	2.15	2.15
7	2.00	2.00	2.00	2.00	2.10	2.20	2.00	2.00	3.80	2.15	2.15	2.15
8	2.00	2.00	2.00	2.00	2.00	2.20	2.00	2.00	2.25	2.10	2.15	2.15
9	2.00	2.00	2.00	2.00	2.00	2.20	2.00	2.00	2.20	2.10	2.15	2.15
10	2.00	2.00	2.00	2.00	2.00	2.20	2.00	2.00	2.20	2.10	2.15	2.15
11	2.05	2.00	2.00	2.00	2.00	2.20	2.00	2.00	2.20	2.10	2.15	2.15
12	2.10	2.00	2.00	2.00	2.00	2.10	2.00	2.00	2.20	2.10	2.15	2.10
13	2.10	2.00	2.00	2.20	2.00	2.10	2.00	2.00	2.10	2.10	2.15	2.10
14	2.10	2.00	2.00	2.10	2.00	2.10	2.00	2.00	2.20	2.10	2.15	2.10
15	2.10	2.00	2.00	2.00	2.00	2.10	2.00	2.00	2.20	2.10	2.15	2.10
16	2.10	2.00	2.00	2.00	2.00	2.10	2.00	2.00	2.20	2.10	2.15	2.10
17	2.10	2.00	2.00	2.00	2.00	2.10	2.00	2.00	2.20	2.10	2.15	2.05
18	2.00	2.00	2.00	1.90	5.95	2.10	2.00	2.00	2.20	2.10	2.15	2.10
19	2.00	2.00	2.00	1.90	4.05	2.10	2.00	2.00	2.20	2.10	2.15	2.10
20	2.00	2.00	2.00	1.90	2.95	2.10	2.00	2.00	2.20	2.10	2.15	2.10
21	2.00	2.00	2.00	1.90	2.65	2.10	2.00	2.00	2.20	2.10	2.15	2.10
22	2.00	2.00	2.00	1.90	2.45	2.00	2.00	2.00	2.20	2.10	2.15	2.05
23	2.00	2.00	2.00	1.90	2.40	2.00	2.00	2.00	2.20	2.10	2.15	2.05
24	2.00	2.00	2.00	1.90	2.40	2.00	2.00	2.00	2.20	2.10	2.15	2.05
25	2.00	2.00	2.00	1.90	2.25	2.00	2.00	2.00	2.20	2.10	2.15	2.05
26	2.00	2.00	2.00	1.90	2.20	2.00	2.00	2.00	2.15	2.10	2.10	2.05
27	2.00	2.00	2.00	1.90	2.20	2.00	2.60	2.00	2.15	2.10	2.10	2.05
28	2.00	2.00	2.00	1.90	2.20	2.00	2.15	2.00	2.15	2.10	2.10	2.05
29	2.00	.....	2.00	1.90	2.20	2.00	2.05	2.00	2.15	2.10	2.10	2.05
30	2.00	.....	2.00	1.90	2.20	2.00	2.00	2.00	2.15	2.10	2.10	2.05
31	2.00	.....	2.00	.....	2.20	.....	2.00	2.00	.....	2.10	.....	2.05

Estimated monthly discharge of Devils River at Devilsriver, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	500	470	488	29,990
February	500	450	480	26,638
March	500	490	494	30,367
April	590	440	469	27,907
May	5,380	440	815	50,102
June	560	435	491	29,207
July	880	420	443	27,213
August	430	405	414	25,458
September	2,200	405	510	30,367
October	530	420	433	26,618
November	660	390	436	29,514
December	535	380	414	25,438
The year	5,380	380	491	355,219

PECOS RIVER NEAR MOORHEAD, TEX.

This station was established by the International (Water) Boundary Commission in April, 1900. It is near Moorhead, immediately above the high bridge of the Southern Pacific Railway.

Discharge measurements of Pecos River near Moorhead, Tex.

[Made by James P. Hague, J. D. Dillard, and A. L. Wilcox.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 4	1.4	608	June 4	0.7	231
January 8	2.1	967	June 8	.7	231
January 13	2.1	943	June 12	.7	240
January 16	1.9	842	June 17	1.5	543
January 25	1.6	581	June 20	1.1	351
January 28	1.6	536	June 25	1.7	642
February 1	1.6	499	June 29	1.2	394
February 8	1.4	502	July 4	.9	282
February 12	1.65	636	July 9	.8	253
February 15	1.6	612	July 13	.7	237
February 19	1.6	609	July 17	1.7	594
February 22	1.7	638	July 21	2.35	1,067
March 4	1.3	487	July 25	2.9	1,531
March 7	1.3	487	July 30	3.6	2,036
March 11	1.3	457	August 3	4.2	2,763
March 14	1.2	426	August 7	2.45	1,202
March 19	1.2	362	August 12	1.8	729
March 22	1.2	360	August 16	1.9	784
March 26	1.15	344	August 21	2.0	851
March 30	1.1	370	August 25	1.6	579
April 1	1.1	378	August 29	1.3	465
April 6	1.0	343	September 2	1.2	374
April 10	.9	298	September 6	2.05	885
April 13	1.85	718	September 10	1.55	602
April 20	.9	311	September 14	1.85	742
April 25	.9	277	September 18	1.6	630
April 30	.9	250	September 20	1.55	565
May 3	1.4	460	September 25	1.35	477
May 7	1.35	430	September 30	1.3	431
May 11	.9	249	October 4	1.45	464
May 17	.8	235	October 8	1.3	420
May 21	1.1	322	October 12	1.3	423
May 25	.9	255	October 16	1.3	429
May 30	.8	231	October 20	1.3	416

Discharge measurements of Pecos River near Moorhead, Tex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
October 24	1.25	421	November 28	1.3	392
October 28	1.2	404	December 3	1.3	365
November 3	1.5	521	December 7	1.3	375
November 7	1.3	440	December 11	1.55	507
November 11	1.25	423	December 16	1.4	398
November 15	1.3	420	December 22	1.4	420
November 20	1.25	412	December 27	1.4	410

Daily gage height, in feet, of Pecos River near Moorhead, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.40	1.60	1.60	1.10	0.90	1.05	1.25	3.85	1.20	1.20	1.20	1.30
2	1.40	1.30	1.40	1.10	.90	.90	1.10	3.95	1.25	1.25	1.20	1.30
3	1.40	1.30	1.30	1.10	1.20	.80	1.10	4.20	1.80	1.85	1.45	1.30
4	1.40	1.30	1.30	1.00	.90	.70	.90	4.30	1.45	1.40	1.45	1.30
5	1.30	1.30	1.30	1.00	.90	.70	.90	3.35	4.05	1.40	1.35	1.30
6	1.30	1.20	1.30	1.00	1.35	.70	.90	2.70	2.15	1.40	1.30	1.30
7	1.30	1.30	1.30	1.00	1.40	.70	.85	2.40	1.85	1.30	1.30	1.30
8	1.95	1.40	1.30	1.00	1.15	.70	.80	2.25	1.80	1.30	1.30	1.30
9	2.05	1.40	1.30	1.00	1.10	.70	.80	2.05	1.65	1.30	1.35	1.35
10	2.00	1.40	1.30	.90	1.00	.70	.80	1.95	1.75	1.20	1.40	1.55
11	2.00	1.40	1.30	.90	.90	.70	.75	1.85	1.90	1.20	1.30	1.50
12	2.20	1.60	1.30	.90	.90	.70	.70	1.80	2.05	1.30	1.30	1.60
13	2.10	1.65	1.30	2.20	.90	.80	.70	1.80	2.05	1.30	1.30	1.50
14	2.10	1.60	1.20	3.25	.90	.70	.70	1.90	1.85	1.30	1.30	1.50
15	2.10	1.60	1.20	1.60	.90	.60	.75	1.85	1.65	1.20	1.30	1.50
16	1.90	1.60	1.20	1.70	.90	.70	.80	2.00	1.60	1.30	1.20	1.40
17	1.80	1.60	1.20	1.30	.85	1.50	2.00	2.55	1.70	1.30	1.20	1.40
18	1.80	1.60	1.20	1.10	10.40	1.30	2.90	2.50	2.30	1.30	1.20	1.40
19	1.80	1.60	1.20	1.10	1.35	1.10	2.90	2.25	1.75	1.30	1.25	1.40
20	1.60	1.60	1.20	.90	1.10	1.05	2.50	2.15	1.55	1.30	1.30	1.40
21	1.60	1.60	1.20	.90	1.10	1.00	2.30	2.00	1.50	1.30	1.30	1.40
22	1.60	1.70	1.20	.90	1.10	.95	2.30	1.90	1.50	1.30	1.40	1.40
23	1.60	1.70	1.20	.90	1.00	.80	2.30	1.85	1.40	1.30	1.30	1.40
24	1.60	1.70	1.20	.90	.90	1.55	2.50	1.65	1.45	1.20	1.30	1.40
25	1.60	1.60	1.20	.90	.90	1.60	3.00	1.55	1.40	1.20	1.30	1.40
26	1.60	1.60	1.15	.90	.90	1.35	3.35	1.50	1.35	1.20	1.30	1.40
27	1.60	1.60	1.15	.90	.90	1.20	3.50	1.40	1.30	1.20	1.30	1.40
28	1.60	1.60	1.15	.90	.90	1.05	3.50	1.35	1.30	1.20	1.30	1.40
29	1.60	.....	1.15	.90	.80	1.20	3.55	1.30	1.30	1.20	1.30	1.40
30	1.60	.....	1.10	.90	.80	1.05	3.60	1.25	1.30	1.20	1.30	1.40
31	1.60	.....	1.10	.....	1.20	.....	3.75	1.20	.....	1.20	.....	1.40

Estimated monthly discharge of Pecos River near Moorhead, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	1,000	450	675	41,514
February	640	430	559	31,041
March	610	340	421	25,884
April	1,760	250	411	24,466
May	11,100	230	640	39,342
June	590	210	319	18,952
July	2,160	235	885	54,387
August	2,880	425	1,074	66,020
September	2,370	375	678	40,334
October	740	405	430	26,420
November	500	390	425	25,269
December	535	365	414	25,478
The year	11,100	210	578	419,107

PECOS RIVER, MARGUERETTA FLUME, AND WEST VALLEY DITCH, NEAR PECOS, TEX.

The summer flow of Pecos River is largely dependent upon numerous springs, which occur in the limestone country in the vicinity of Roswell and below. Owing to the numerous diversions for irrigating purposes, however, the river would be dry in the summer where it crosses into Texas were it not for the waters which are gradually returning to the river through seepage. This water, unfortunately, is impregnated to a considerable extent with alkali, which renders it undesirable for irrigating purposes.

The station on the Pecos River was established January 1, 1898, by Thomas U. Taylor, and is located about 6 miles above Pecos, Tex., at the flume of the Margueretta Canal Company. This canal diverts the water from the Pecos River 3 miles above the flume from the west side of the river. The main canal flows for 3 miles on the west side of the river and then is taken by the flume across the Pecos River to the east side. However, before it reaches the flume the West Valley canal is taken out of the main canal and is made to carry water to the alfalfa farms on the west side of the river. The gage consists of a graduated strip of wood attached to one of the vertical bents of the flume on the upper side of the same. The bench mark is on the top of the west abutment or pier on the north side, and its elevation is

20.70 feet above the datum of the gage. The channel at this point is nearly straight, the water at low stages rather sluggish, the banks high, and the bottom sandy. The gage heights on the flume are obtained by measuring the depths of the water in the flume at the west end. The zero of this gage is at the bottom of the flume. The gages of the river have no connection with each other except that they are geographically at the same place on the river and have the same observer, Willard H. Dennis, who reads both gages. For the years 1901 and 1902 Mr. Dennis has also taken the measurements of the flow of the Pecos, the flume, and the ditch at this station. The measurements are made above the flume by wading, a wire being stretched across the river and tagged every 4 feet. A full description of the canals and ditches in this section is given on page 62 of Water-Supply Paper No. 13.

Discharge measurements of Pecos River and Margueretta flume near Pecos, Tex.

Date.	Gage height Pecos River.	Pecos River discharge.	Margueretta flume discharge.
1902.	*Feet.*	*Second-feet.*	*Second-feet.*
September 29	2.00	119	.....
October 3	2.00	109	115
October 6	2.40	153	106
October 10	2.20	132	117
October 14	2.00	103	132
October 18	2.10	127	123
October 21	2.15	120	126
October 24	2.00	107	.....
October 27	2.30	162	130
November 3	1.90	97	126
December 3	3.60	390	82
December 4	3.30	306	87
December 6	2.80	221	99

Discharge of West Valley ditch near Pecos, Tex.

Date.	Discharge.	Date.	Discharge.	Date.	Discharge.
1902.	*Sec.-feet.*	1902.	*Sec.-feet.*	1902.	*Sec.-feet.*
March 24	10	June 16	16	October 6	6
March 31	10	June 23	14	October 10	9
April 8	10	June 29	14	October 13	14
April 14	14	July 6	10	October 14	13
April 21	16	August 24	16	October 18	15
April 28	14	August 31	10	October 19	12
May 5	16	September 7	16	October 21	11
May 12	14	September 14	16	October 26	7
May 18	16	September 21	14	October 27	8
May 26	16	September 28	14	November 2	7
June 2	18	October 3	14	November 3	7
June 9	14	October 5	9		

Daily gage height, in feet, of Pecos River near Pecos, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.90	2.80	2.60	0.90	0.40	0.50	1.10	4.45	2.00	2.00	1.90	2.60
2	5.10	2.80	2.70	.90	.40	.50	1.10	3.85	2.00	2.00	1.95	3.45
3	5.00	2.70	2.70	.85	.40	.50	1.10	3.65	2.00	2.10	2.00	3.65
4	5.00	3.30	2.70	.85	.40	.50	2.00	3.55	2.00	2.10	2.00	3.55
5	4.95	3.50	2.65	.85	.40	.50	1.65	3.20	3.15	2.30	2.00	3.30
6	5.00	3.50	2.60	.90	.40	.50	1.35	3.05	3.30	2.45	2.00	2.75
7	4.90	3.55	2.55	.90	.40	3.65	1.10	4.00	2.90	2.20	2.00	2.80
8	4.30	3.55	2.45	.80	.40	3.55	1.10	4.20	2.75	2.10	2.00	2.80
9	4.00	3.50	2.40	.65	.40	4.75	1.10	3.55	3.15	2.10	2.05	2.75
10	3.95	3.45	2.40	.55	.40	6.50	1.75	4.00	3.35	2.15	2.10	2.80
11	3.85	2.95	2.35	.50	.40	5.25	5.30	5.05	3.15	2.15	2.10	2.75
12	3.45	3.00	2.30	.50	.40	3.10	9.50	7.65	3.10	2.10	2.10	2.60
13	3.15	3.70	2.30	.50	.50	1.95	12.00	5.15	2.90	2.10	2.10	2.85
14	3.00	4.05	2.30	.50	.55	1.50	7.70	4.25	2.80	2.05	2.00	2.75
15	2.95	4.05	2.25	.50	.65	1.15	6.00	3.75	2.45	2.10	2.00	2.70
16	2.90	3.90	2.20	.50	.80	1.05	5.10	3.55	2.10	2.10	2.00	2.70
17	2.80	3.90	2.20	.40	.70	1.00	4.55	3.40	2.05	2.10	2.00	2.70
18	2.80	3.80	2.05	.40	.70	5.50	3.95	3.35	2.00	2.10	2.00	2.70
19	2.80	3.45	1.85	.40	.70	6.55	3.85	3.25	2.05	2.25	2.00	2.70
20	2.75	3.10	1.65	.40	.65	3.70	6.45	3.05	2.10	2.30	2.00	2.70
21	2.70	3.10	1.50	.40	.50	2.85	8.70	2.90	2.45	2.10	2.00	2.60
22	2.70	3.05	1.50	.40	.50	2.50	8.50	2.70	2.50	2.10	2.00	2.60
23	2.70	2.95	1.50	.40	.50	1.75	11.70	2.55	2.40	2.10	2.00	2.60
24	2.70	2.90	1.55	.40	.50	1.50	13.90	2.50	2.60	2.00	2.10	2.60
25	2.70	2.85	1.50	.40	.50	1.30	12.35	2.50	2.70	2.30	2.15	2.60
26	2.70	2.80	1.50	.40	.50	1.15	9.40	2.35	2.60	2.30	2.00	2.60
27	2.70	2.70	1.50	.40	.50	1.10	7.95	2.30	2.40	2.30	2.00	2.70
28	2.70	2.60	1.40	.40	.50	1.10	7.70	2.20	2.15	2.30	2.00	2.70
29	2.70	.....	1.30	.40	.50	1.10	7.35	2.15	2.00	2.15	2.15	2.70
30	2.70	.....	1.25	.40	.50	1.10	6.85	2.05	2.00	2.05	2.40	2.75
31	2.70	.....	1.05	.....	.50	.....	5.90	2.00	.....	2.00	.....	3.00

Daily gage height, in feet, of Margueretta flume near Pecos, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.95	2.52	2.50	2.00	1.75	1.85	1.90	0.00	2.30	2.15	2.20	2.15
2	3.00	2.50	2.50	1.95	1.85	1.95	1.75	.00	2.30	2.25	2.30	2.15
3	3.00	2.50	2.60	1.85	2.00	1.50	1.75	.60	2.30	2.35	2.25	1.95
4	3.00	2.65	2.60	1.85	1.85	1.45	2.05	1.25	2.15	2.20	2.30	2.05
5	3.05	2.60	2.60	1.60	1.70	1.62	2.20	1.55	1.60	2.40	2.35	2.15
6	3.10	2.55	2.60	1.60	1.65	1.65	1.65	1.90	3.00	2.30	2.30	2.10
7	3.00	2.55	2.60	1.55	1.70	2.50	1.30	2.30	1.85	2.00	2.30	2.05
8	2.78	2.55	2.58	1.50	1.70	2.50	1.30	2.85	1.10	2.00	2.30	2.10
9	2.85	1.40	2.55	1.50	1.70	2.55	1.95	.85	1.25	2.10	2.25	2.15
10	2.85	1.40	2.60	1.40	1.55	1.75	1.80	.95	1.35	2.10	2.20	2.20
11	2.85	1.25	2.52	1.65	1.50	1.95	1.45	3.00	1.15	2.05	2.20	2.20
12	2.75	1.35	2.42	2.10	1.60	2.30	1.90	.....	1.50	2.05	2.20	2.20
13	2.80	1.72	2.50	2.25	1.60	2.32	3.20	3.00	1.40	2.10	2.20	2.20
14	2.78	2.60	2.45	2.20	1.60	2.32	2.50	3.00	.80	2.10	2.15	2.20
15	2.78	2.50	2.25	2.00	1.75	1.78	1.10	2.90	1.00	2.10	2.15	2.30
16	2.80	2.40	2.25	1.75	2.10	1.50	.60	2.80	1.70	2.10	2.10	2.25
17	2.80	2.40	2.40	1.75	2.05	1.60	.15	2.25	1.70	2.20	2.10	2.20
18	2.90	2.40	2.40	1.80	2.00	2.25	.00	2.25	1.50	2.20	2.10	2.20
19	2.85	2.35	2.40	1.80	1.85	2.40	.00	2.15	2.65	2.10	2.10	2.20
20	2.80	2.20	2.35	1.90	1.60	2.50	1.15	1.65	2.10	2.10	2.10	2.20
21	2.80	2.20	2.48	1.90	1.50	2.45	2.05	2.35	1.80	2.30	2.15	2.20
22	2.85	2.20	2.40	1.70	1.60	2.20	3.10	2.15	1.80	2.30	2.20	2.30
23	2.80	2.20	2.40	1.40	1.60	2.30	3.35	1.60	1.85	2.30	2.20	2.30
24	2.80	2.10	1.85	1.35	1.75	2.20	3.65	1.50	2.10	2.40	2.20	2.30
25	2.75	2.30	1.90	1.45	2.00	2.05	3.50	1.50	2.20	2.45	2.20	2.30
26	2.75	2.40	2.00	1.65	1.95	1.85	3.10	1.50	2.05	2.35	2.20	2.20
27	2.75	2.50	2.00	1.65	1.70	1.75	2.30	1.60	2.10	2.35	2.15	2.30
28	2.75	2.40	2.05	1.75	1.65	1.68	2.50	2.05	2.10	2.40	2.15	2.30
29	2.75	.....	2.10	1.60	1.60	1.65	2.00	2.20	2.10	2.30	2.20	2.30
30	2.75	.....	1.80	1.65	1.45	1.90	.55	2.25	2.05	2.30	2.00	2.30
31	2.72	.....	1.90	.....	1.55	.....	.00	2.30	.....	2.30	.....	2.30

Rating table for Pecos River near Pecos, Tex., for 1902. [a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.7	77	3.0	240	4.3	574	8.0	2,022
1.8	83	3.1	260	4.4	606	8.5	2,222
1.9	90	3.2	280	4.5	640	9.0	2,422
2.0	98	3.3	302	4.6	674	9.5	2,622
2.1	107	3.4	324	4.7	710	10.0	2,822
2.2	117	3.5	348	4.8	746	10.5	3,022
2.3	128	3.6	372	4.9	784	11.0	3,222
2.4	140	3.7	398	5.0	822	11.5	3,422
2.5	154	3.8	425	5.5	1,022	12.0	3,622
2.6	170	3.9	453	6.0	1,222	12.5	3,822
2.7	186	4.0	482	6.5	1,422	13.0	4,022
2.8	204	4.1	512	7.0	1,622	13.5	4,222
2.9	222	4.2	542	7.5	1,822		

[a] This is made up from measurements of the river only; does not include ditch or flume.

Estimated monthly discharge of Pecos River near Pecos, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	862	185	381	23,427
February	497	170	304	16,883
March 1 to 19 [a]			144	5,482
June 7 to 13 and 18 to 23 [a]			577	14,878
July 10 to 31 [a]			1,881	82,080
August	1,882	98	383	23,550
September	313	98	167	9,937
October	147	98	112	6,887
November	140	90	102	6,069
December	385	170	205	12,595

[a] As no discharge measurements have been made at low water, discharges for gage heights of less than 1.7 feet can not be computed. Gage height of 1.7 feet corresponds to a discharge of 77 second-feet. For periods not covered by above table discharges were less than 77 second-feet. See table of gage heights.

RIO GRANDE AT LANGTRY, TEX.

This station was established in April, 1900, by the International (Water) Boundary Commission. It is located one-half mile south of Langtry station, on the Southern Pacific Railway, and is about 440 miles below El Paso, Tex., at the eastern end of the canyon section of the Rio Grande, and a short distance to the west of the mouth of Pecos River, one of the principal tributaries of the Rio Grande.

Discharge measurements of the Rio Grande at Langtry, Tex.

[Made by Jas. P. Hague and J. D. Dillard.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 3	0.9	806	February 14	0.95	542
January 7	.9	684	February 18	1.0	577
January 9	.9	592	February 21	.9	512
January 12	.9	649	February 25	.9	515
January 17	1.0	589	February 28	.9	531
January 20	1.0	651	March 3	.8	484
January 24	.9	554	March 6	.8	480
January 27	1.0	636	March 10	.8	458
January 31	.95	563	March 13	.8	454
February 3	1.0	571	March 15	.8	447
February 7	1.0	563	March 18	.75	408
February 11	.95	550	March 21	.75	424

Discharge measurements of the Rio Grande at Langtry, Tex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
March 25	.7	391	August 8	2.95	3,060
March 27	.7	403	August 13	2.3	2,043
March 31	.65	370	August 18	3.95	5,066
April 2	.65	362	August 22	4.0	5,263
April 5	.65	373	August 26	5.9	9,328
April 9	.65	361	August 30	5.45	8,268
April 12	.65	368	September 3	5.15	7,843
April 17	1.0	591	September 7	7.95	14,979
April 21	.7	378	September 11	10.65	23,471
April 24	.65	318	September 20	3.8	4,749
April 28	.65	304	September 24	3.1	3,261
May 2	.6	283	September 28	2.6	2,360
May 5	1.35	845	September 30	2.7	2,532
May 8	.65	310	October 3	2.75	2,523
May 12	.6	286	October 7	2.35	1,957
May 15	1.1	656	October 11	2.8	2,661
May 18	2.2	1,899	October 15	2.35	2,011
May 22	.75	362	October 19	2.0	1,540
May 26	.7	329	October 23	1.8	1,317
May 31	1.7	1,189	October 27	1.7	1,202
June 5	.75	358	October 31	1.65	1,142
June 9	.7	305	November 4	1.7	1,222
June 13	1.35	797	November 8	1.8	1,324
June 17	1.0	501	November 12	1.5	1,032
June 21	1.8	1,269	November 16	1.4	939
June 26	.7	316	November 20	1.35	868
July 1	1.9	1,360	November 24	1.35	863
July 5	.85	382	November 28	1.3	815
July 10	2.95	3,067	December 1	1.3	779
July 14	5.0	6,696	December 5	1.9	1,434
July 18	2.35	2,125	December 10	1.35	839
July 22	3.0	2,997	December 15	1.35	831
July 26	8.0	12,962	December 20	1.4	893
July 31	5.45	7,599	December 26	1.35	845
August 4	3.4	3,902			

Daily gage height, in feet, of the Rio Grande at Langtry, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	0.90	0.90	0.90	0.65	0.65	1.00	1.65	4.75	5.90	2.80	2.55	1.30
2	.90	1.00	.80	.65	.60	.85	.90	3.80	5.80	3.10	1.95	1.40
3	.90	1.00	.80	.65	.60	.80	1.00	3.40	5.45	3.40	2.15	1.40
4	.90	1.00	.80	.65	.70	.80	.90	3.25	6.40	3.20	1.95	1.70
5	.90	1.00	.80	.65	1.55	.75	.85	2.90	7.00	3.40	2.85	1.40
6	.90	1.00	.80	.65	.80	.75	.90	3.70	7.85	2.65	2.55	1.60
7	.90	1.00	.80	.65	.65	.70	1.10	3.70	8.10	2.40	2.00	1.60
8	.90	1.00	.80	.65	.65	.70	1.20	2.80	10.40	2.20	1.80	1.50
9	.90	1.00	.80	.65	.65	.70	2.20	2.65	14.65	2.20	1.65	1.50
10	.90	1.00	.80	.65	.65	1.00	3.05	2.50	12.95	2.10	1.55	1.35
11	.90	.95	.80	.65	.65	1.35	2.80	2.50	10.65	2.75	1.50	1.35
12	.90	.95	.80	.65	.60	1.70	2.90	2.45	10.05	2.70	1.50	1.30
13	.90	.95	.80	2.95	.60	1.40	7.00	4.65	8.85	2.60	1.45	1.30
14	1.10	.95	.80	1.00	.75	1.25	4.80	6.25	7.25	2.55	1.45	1.30
15	1.10	.95	.80	2.15	1.10	1.20	3.90	5.65	6.40	2.30	1.40	1.3
16	1.10	.90	.80	2.05	.95	1.10	3.50	5.25	5.70	2.20	1.40	1.40
17	1.00	.90	.80	1.40	.80	1.10	2.55	4.40	5.05	2.15	1.40	1.40
18	1.00	1.00	.75	.80	2.45	1.45	2.45	3.95	4.35	2.05	1.40	1.4
19	1.00	.90	.75	.80	1.15	1.80	2.95	3.95	4.05	2.00	1.40	1.40
20	1.00	.90	.75	.80	.85	1.80	2.60	4.05	3.95	1.95	1.40	1.40
21	1.00	.90	.75	.80	.80	1.80	3.20	3.95	6.25	1.90	1.35	1.40
22	1.00	.90	.75	.75	.75	1.10	2.90	3.90	5.05	1.85	1.35	1.40
23	1.00	.90	.70	.70	.75	1.00	4.35	3.75	3.55	1.80	1.35	1.40
24	.95	.90	.70	.65	1.30	.85	4.00	4.45	3.05	1.80	1.35	1.4
25	.90	.90	.70	.65	.80	.75	10.45	5.10	2.95	1.75	1.40	1.40
26	.95	.90	.70	.65	.75	.70	7.60	5.90	2.90	1.75	1.70	1.4
27	1.00	.90	.70	.65	.75	.70	7.45	5.15	2.75	1.70	1.40	1.40
28	1.00	.90	.70	.65	.75	.70	7.75	4.60	2.65	1.70	1.30	1.35
29	1.00	.....	.70	.65	1.60	.70	8.10	4.55	2.70	1.70	1.30	1.35
30	1.00	.....	.65	.65	1.60	4.10	5.80	5.60	2.70	1.65	1.30	1.35
31	.90	.....	.65	.....	1.60	.....	5.45	6.40	.....	1.60	.....	1.35

Estimated monthly discharge of the Rio Grande at Langtry, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	820	550	663	40,76[illegible]
February	580	510	542	30,089
March	530	370	435	26,717
April	3,380	305	611	36,367
May	2,250	285	544	33,451
June	5,170	305	745	44,301
July	20,800	380	4,964	305,216
August	10,550	2,250	5,672	348,734
September	38,200	2,440	11,160	664,04[illegible]
October	3,900	1,080	1,948	119,782
November	2,740	815	1,190	70,800
December	1,330	780	917	56,370
The year	38,200	285	2,449	1,776,63[illegible]

RIO GRANDE BELOW PRESIDIO, TEX.

This station was established April 8, 1900, by the International (Water) Boundary Commission. It is 6 miles below Presidio, also below the mouth of Conchos River, and about 215 miles below El Paso. It is at the western end of the canyon section of the Rio Grande. The discharge at this station, minus the discharge at the station above Presidio, Tex., gives the discharge of the Conchos, except at rare intervals when some rain water enters the Rio Grande from the north.

Discharge measurements of the Rio Grande below Presidio, Tex. [a]

[Made by S. D. Church and J. P. Hague.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
March 3	4.2	98	June 11	4.7	26
March 6	4.2	85	June 13	5.2	74
March 10	4.1	77	June 16	4.7	30
March 12	4.0	58	June 20	4.5	15
March 14	3.9	52	July 2	8.55	2,275
March 17	3.9	51	July 4	5.0	170
March 19	3.9	48	July 7	7.3	517
March 21	3.8	41	July 9	8.9	3,086
March 24	3.8	35	July 14	8.05	2,156
March 26	3.7	30	July 16	8.2	2,265
March 28	3.7	32	July 18	7.65	1,473
April 2	3.7	32	July 21	9.4	4,883
April 4	3.7	32	July 22	11.0	9,539
April 7	3.7	29	July 24	12.15	13,706
April 9	3.6	26	July 26	12.2	14,352
April 11	3.6	25	July 28	11.4	10,579
April 14	3.6	22	July 30	9.6	5,313
April 16	3.6	23	August 1	8.9	3,601
April 18	3.6	22	August 4	7.6	1,854
April 21	3.5	20	August 6	8.3	1,909
April 23	3.5	21	August 8	7.7	1,528
April 25	3.5	20	August 10	8.3	1,794
May 5	3.4	13	August 12	10.8	7,030
May 7	3.4	12	August 14	10.2	5,999
May 9	3.4	11	August 16	10.25	6,082
May 12	3.4	10	August 18	9.75	4,971
May 20	3.5	8	August 20	9.85	5,426
June 6	3.9	7	August 22	9.8	5,416
June 9	6.85	405	August 24	11.3	8,831

[a] No measurements for January and February, 1902. Daily flow computed from gage record.

Discharge measurements of the Rio Grande below Presidio, Tex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
August 26	10.0	5,776	October 20	6.2	906
August 28	11.4	10,361	October 23	6.05	845
August 30	11.45	10,522	October 25	6.0	815
September 1	10.15	5,781	October 27	5.8	721
September 4	12.85	15,932	October 30	6.05	834
September 8	16.75	32,962	November 1	5.7	711
September 9	13.7	23,771	November 4	5.65	697
September 11	12.5	17,686	November 7	5.4	587
September 15	10.5	7,169	November 10	5.4	588
September 17	8.3	3,669	November 13	5.2	532
September 19	8.2	3,396	November 16	5.15	485
September 20	7.7	2,652	November 19	5.1	451
September 22	7.5	2,125	November 22	5.05	446
September 24	7.5	2,125	November 25	5.0	420
September 25	7.5	2,157	November 28	5.0	413
September 27	7.3	1,933	December 1	6.5	974
September 29	7.15	1,742	December 6	5.4	542
October 1	7.1	1,617	December 9	5.2	498
October 3	6.85	1,438	December 12	5.2	492
October 6	6.65	1,245	December 15	5.35	574
October 8	7.6	2,230	December 18	5.3	530
October 10	7.2	1,963	December 21	5.25	481
October 13	6.8	1,758	December 24	5.05	401
October 15	6.6	1,080	December 27	5.05	415
October 17	6.4	1,010	December 30	5.05	404

Daily gage height, in feet, of the Rio Grande below Presidio, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.00	4.80	4.20	3.70	3.45	3.90	4.75	8.70	10.60	7.10	5.80	6.75
2	4.95	4.75	4.20	3.70	3.40	3.90	8.15	8.20	10.20	8.15	6.65	5.55
3	4.90	4.65	4.20	3.70	3.40	3.90	5.50	7.90	11.10	6.85	7.25	5.25
4	4.80	4.60	4.20	3.70	3.40	3.90	5.00	7.65	12.85	6.80	5.80	5.20
5	4.90	4.60	4.20	3.70	3.40	3.90	5.00	7.70	14.25	6.80	5.65	5.15
6	5.15	4.60	4.20	3.70	3.40	3.90	6.60	8.45	16.50	6.65	5.50	5.35
7	5.40	4.70	4.20	3.70	3.40	3.90	7.45	7.55	17.95	7.45	5.45	5.25
8	5.35	4.65	4.15	3.70	3.40	5.60	8.40	7.70	16.65	7.65	5.40	5.30
9	5.25	4.55	4.10	3.60	3.40	7.40	9.10	7.50	14.00	7.45	5.40	5.30
10	5.15	4.45	4.10	3.60	3.40	5.30	11.60	8.40	12.90	7.25	5.40	5.20
11	5.10	4.40	4.10	3.60	3.40	4.70	12.20	11.50	12.65	7.10	5.30	5.20
12	5.10	4.40	4.00	3.60	3.40	4.70	10.30	11.40	12.45	6.90	5.30	5.30
13	5.10	4.35	3.90	3.60	3.40	5.20	9.15	10.40	12.15	6.80	5.15	5.15
14	5.00	4.30	3.90	3.60	4.35	5.10	8.05	10.30	11.05	6.70	5.20	5.20

Daily gage height, in feet, of the Rio Grande below Presidio, Tex.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
15	5.00	4.30	3.90	3.60	3.80	4.85	7.70	10.10	10.55	6.60	5.20	5.35
16	4.90	4.30	3.90	3.60	3.60	4.70	8.20	10.20	9.35	6.50	5.15	5.40
17	4.80	4.30	3.90	3.60	3.60	4.80	7.80	9.70	8.50	6.40	5.10	5.30
18	4.90	4.30	3.90	3.60	3.50	4.55	7.65	9.90	8.30	6.30	5.10	5.30
19	5.15	4.30	3.90	3.50	3.50	4.55	7.40	9.90	8.15	6.20	5.10	5.30
20	5.15	4.30	3.90	3.50	3.50	4.90	9.80	9.85	7.75	6.20	5.10	5.20
21	5.00	4.30	3.80	3.50	3.50	4.40	9.40	10.00	7.60	6.20	5.10	5.25
22	5.00	4.25	3.80	3.50	3.50	4.40	12.25	9.95	7.50	6.10	5.05	5.10
23	4.90	4.20	3.80	3.50	3.50	4.40	12.60	10.80	7.60	6.05	5.00	5.10
24	4.80	4.20	3.80	3.50	3.50	4.40	12.10	11.40	7.50	6.00	5.00	5.05
25	5.10	4.20	3.80	3.50	5.55	4.40	12.10	11.40	7.45	6.00	5.00	5.05
26	5.30	4.20	3.70	3.50	4.00	4.40	12.75	10.20	7.50	5.90	5.00	5.05
27	5.30	4.20	3.70	3.50	3.90	4.40	12.00	10.80	7.35	5.80	5.00	5.05
28	5.20	4.20	3.70	3.50	3.90	4.40	11.50	11.50	7.25	5.80	5.00	5.05
29	5.15	.....	3.70	3.50	3.90	4.30	10.50	11.55	7.15	5.80	5.00	5.05
30	5.00	.....	3.70	3.50	3.90	4.30	9.60	11.40	7.10	6.00	5.00	5.05
31	4.90	.....	3.70	.....	3.90	.....	8.95	11.30	.....	5.85	.....	5.00

Estimated monthly discharge of the Rio Grande below Presidio, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	350	220	259	15,907
February	220	100	141	7,835
March	100	30	59	3,610
April	30	20	24	1,448
May	15	10	11	674
June	625	10	48	2,866
July	17,100	40	5,918	363,888
August	10,900	1,300	5,702	350,618
September	45,000	1,680	10,755	639,947
October	3,320	720	1,305	80,212
November	2,000	415	590	35,098
December	1,070	380	493	30,317
The year	45,000	10	2,109	1,532,420

RIO GRANDE ABOVE PRESIDIO, TEX.

This station was established April 4, 1900, by the International (Water) Boundary Commission. It is 7 miles above Presidio and above the mouth of Conchos River, one of the principal tributaries of the Rio Grande, and is about 200 miles below El Paso. Its location is far enough above the mouth of Conchos River to be free from the effects of backwater from that stream.

Discharge measurements of the Rio Grande above Presidio, Tex.[a]

[Made by J. P. Hague.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
July 5	1.4	53	August 11	5.5	1,254
July 10	4.0	857	August 13	2.65	188
July 12	4.1	943	August 15	2.4	165
July 15	2.55	289	September 2	2.0	107
July 17	1.95	143	September 5	3.45	635
July 19	1.55	61	September 8	2.1	186
July 23	7.3	2,683	September 10	2.0	99
July 25	5.6	1,326	October 12	.7	15
July 29	2.15	193	November 3	1.5	60
July 31	1.75	62	November 5	1.0	13
August 2	.9	14	November 8	.8	9

[a] No measurements made at this station during January, February, and December, 1902. Daily flow computed from gage record. River was dry during May and June, 1902.

Daily gage height, in feet, of the Rio Grande above Presidio, Tex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.20	1.30	.....	.....	.....	.....	.....	1.60	3.55	.....	0.90	2.30
2	1.20	1.30	.....	.....	.....	.....	3.05	0.95	3.55	.....	3.55	0.70
3	1.10	1.25	.....	.....	.....	.....	0.75	.....	4.85	.....	1.75	0.30
4	1.00	1.20	.....	.....	.....	.....	1.95	.....	4.95	.....	1.20	.....
5	1.10	1.20	.....	.....	.....	1.20	1.40	.....	3.40	1.65	1.00	.....
6	1.35	1.30	.....	.....	.....	.....	.....	.....	4.35	0.75	0.90	.....
7	1.60	1.40	.....	.....	.....	.....	.....	.....	3.65	.....	1.05	.....
8	1.50	1.40	.....	.....	.....	0.55	.....	.....	2.15	.....	0.85	.....
9	1.50	1.30	.....	.....	.....	.....	.....	.....	2.00	.....	0.25	.....
10	1.40	1.25	.....	.....	.....	.....	4.05	1.20	1.90	.....	.....	.....
11	1.40	1.20	.....	.....	.....	.....	6.45	5.50	0.80	.....	.....	.....
12	1.40	1.10	.....	.....	.....	.....	3.90	5.20	.....	0.60	.....	.....
13	1.40	0.90	.....	.....	.....	.....	2.75	2.50	.....	.....	.....	.....
14	1.30	0.70	.....	.....	.....	.....	2.30	3.10	.....	.....	.....	.....
15	1.30	0.50	.....	.....	.....	.....	2.55	2.20	.....	.....	.....	.....
16	1.20	0.30	.....	.....	.....	.....	2.15	1.15	.....	.....	.....	.....
17	1.10	(a)	.....	.....	.....	.....	1.85	.....	.....	.....	.....	.....
18	1.30	.....	.....	.....	.....	.....	1.50	.....	.....	.....	.....	.....
19	1.50	.....	.....	.....	.....	.....	1.50	.....	.....	.....	.....	.....
20	1.50	.....	.....	.....	.....	.....	3.20	.....	.....	.....	.....	.....
21	1.40	.....	.....	.....	.....	.....	5.25	.....	.....	.....	.....	.....
22	1.40	.....	.....	.....	.....	.....	4.80	.....	.....	.....	.....	.....
23	1.30	.....	.....	.....	.....	.....	7.40	.....	.....	.....	.....	.....
24	1.20	.....	.....	.....	.....	.....	6.55	.....	.....	.....	.....	.....
25	1.50	.....	.....	.....	.....	.....	5.70	.....	.....	.....	.....	.....
26	1.65	.....	.....	.....	.....	.....	3.70	.....	.....	.....	.....	.....
27	1.70	.....	.....	.....	.....	.....	2.80	.....	.....	.....	.....	.....
28	1.60	.....	.....	.....	.....	.....	2.60	.....	.....	.....	.....	.....
29	1.60	.....	.....	.....	.....	.....	2.30	.....	.....	.....	.....	.....
30	1.50	.....	.....	.....	.....	.....	2.25	.....	.....	.....	.....	.....
31	1.40	.....	.....	.....	.....	.....	1.75	.....	.....	.....	.....	.....

[a] On days for which there are no gage heights the river was dry.

Estimated monthly discharge of the Rio Grande River above Presidio, Tex.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	130	40	77	4,741
February	70	0	29	1,607
March	0	0	0	0
April	0	0	0	0
May	0	0	0	0
June	60	0	3	159
July	2,740	0	568	34,929
August	1,250	0	102	6,288
September	1,080	0	205	12,198
October	70	0	3	198
November	670	0	28	1,676
December	240	0	8	496
The year	2,740	0	85	62,292

RIO GRANDE NEAR FORT HANCOCK, TEX.

This station was established by the International (Water) Boundary Commission March 27, 1900. It is 1½ miles southeast of Fort Hancock, on the Southern Pacific Railway, in the El Paso Valley, and is about 55 miles below El Paso.

Discharge measurements of the Rio Grande near Fort Hancock, Tex.[a]

[Made by A. L. Wilcox and F. W. Carpenter.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
July 21	2.5	6	September 4	4.5	249
July 23	3.0	18	September 6	3.4	81
July 24	2.4	5	September 9	3.2	72
August 30	6.3	808	September 12	2.1	8
September 1	7.0	1,034	October 7	2.5	16

[a] No measurements made at this station during months of January and February.

Daily flow computed from gage heights.
River was dry during March, April, May, and June, 1902.
No measurements were made at this station during November and December, 1902. River was dry.

Daily gage height, in feet, of the Rio Grande near Fort Hancock, Tex.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.80	5.30							6.90	3.35		
2	4.90	5.50							5.85	3.05		
3	5.00	5.60							5.20	2.70		
4	5.10	5.50							4.60	3.65		
5	5.10	5.40							4.00	3.90		
6	5.10	5.30							3.35	2.90		
7	5.20	5.30							3.30	2.35		
8	5.30	5.20							3.20	2.00		
9	5.30	5.10							3.15			
10	5.40	5.20							2.75			
11	5.50	5.20							2.40			
12	5.50	5.20							2.10			
13	5.60	5.30					4.30		2.00			
14	5.70	5.30										
15	5.70	5.30										
16	5.80	5.20										
17	5.80	4.95										
18	5.70	4.75										
19	5.70	4.55							2.45			
20	5.50	4.35					5.40		2.40			
21	5.80	4.00					2.15		2.10			
22	5.75	3.75					4.40					
23	5.80						3.50					
24	5.70						2.40					
25	5.60											
26	5.60											
27	5.60						3.40					
28	5.60						2.60					
29	5.60								5.15			
30	5.50							5.00	4.05			
31	5.40							7.30				

[a] On the days for which no gage heights are given the river was dry.

Estimated monthly discharge of the Rio Grande near Fort Hancock, Tex.[a]

Month.[a]	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	160	40	112	6,883
February	120	0	57	3,154
July	460	0	26	1,587
August 30 and 31	1,090	0	47	2,916
September	1,000	0	122	7,240
October	165	0	17	1,061
The year	1,090	0	32	22,841

[a] For the months for which no figures are given the river was dry.

RIO GRANDE NEAR EL PASO, TEX.

This station was located at the pumping house of the smelter company, 3 miles north of El Paso, Tex. The bed of the stream here is composed of mud, constantly shifting and changing. May 1, 1897, the station was placed under the charge of W. W. Follett, consulting engineer, International (Water) Boundary Commission, and by him removed 1 mile farther up the river to Courchesne's limekiln. The river heights were measured at the masonry pump foundation pier, 150 feet above the kiln. The top of the downstream chisel draft on this pier was assumed to be at a gage height of 15.0 feet, and the distance of the surface of the water below it was measured with a carefully graduated rod. This pier was torn down in October, 1902, and an inclined wooden gage established some 60 feet upstream. This is a 2 by 4 bolted to 1¼-inch steel bars set with cement in holes drilled in solid rock. The graduations are notches cut in the scantling. The B. M. is a one-half-inch iron bolt set in solid rock at the head of the gage. Its top is 13.00 feet above gage datum. The left bank of the river is formed by the loose rock fill of the Atchison, Topeka and Santa Fe Railroad embankment, and will not overflow. The right bank, however, is not so good, being made ground and subject to overflow. The bottom of the river here has also proven unstable, scouring on a rise and filling on a falling river. It is probably the best site for a station in the vicinity of El Paso, however, as the entire river bed is constantly shifting for many miles above and below. On account of this shifting character of the stream, the only accurate method of estimating the daily discharges is by taking a large number of measurements, which was done in 1902 by T. M. Courchesne, J. P. Hague, A. L. Wilcox, F. W. Carpenter, and I. H. Huggett.

Discharge measurements of the Rio Grande near El Paso, Tex. [a]

[Made by T. M. Courchesne, Jas. P. Hague, A. L. Wilcox, and F. W. Carpenter, and I. H. Huggett.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 30	6.3	145	May 2	5.85	64
February 1	6.4	165	May 5	5.4	19
April 18	6.75	262	May 7	5.2	5
April 21	7.0	301	June 3	6.05	134
April 22	6.6	195	June 4 [b]	5.4	17
April 24	6.6	200	August 27	9.0	1,578
April 26	7.3	465	August 28	6.3	937
April 28	7.3	441	August 29	9.8	2,050
April 30	6.3	145	August 31	9.0	1,190

[a] No measurement for March. Water too shallow.
[b] River dry the remainder of month, throughout July, and until August 27.

Discharge measurements of the Rio Grande near El Paso, Tex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
September 2	7.5	645	October 4	5.6	52
September 5	6.2	160	October 6	5.5	47
September 8	5.6	73	October 8	5.35	37
September 10	5.4	23	October 10	5.3	29
September 13	5.1	5	October 15	4.9	8
September 27	7.9	653	October 17	4.85	4
September 28	7.1	369	December 22	5.9	117
September 30	6.4	171	December 24	5.6	80
October 2	6.0	101	December 26	5.2	34
October 3	5.9	85	December 29	4.7	4

No measurements for November.

Daily gage height, in feet, of the Rio Grande near El Paso, Tex.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.30	6.40	4.90	4.90	5.90	.....	.....	.....	8.10	6.15	.....	5.30
2	6.30	6.40	4.90	4.90	5.80	.....	.....	.....	7.50	6.00	.....	5.30
3	6.30	6.30	4.90	4.90	5.75	6.05	.....	.....	7.00	5.95	.....	5.25
4	6.30	6.30	4.90	4.90	5.45	5.25	.....	.....	6.40	5.65	.....	5.20
5	6.30	6.30	4.90	4.90	5.35	5.00	.....	.....	6.20	5.50	.....	5.30
6	6.30	6.20	4.90	4.90	5.20	.....	.....	.....	6.00	5.45	.....	5.40
7	6.30	6.20	4.90	4.90	5.20	.....	.....	.....	5.80	5.40	.....	5.35
8	6.30	6.20	4.90	4.90	5.20	.....	.....	.....	5.60	5.40	.....	5.25
9	6.30	6.10	4.90	4.90	5.20	.....	.....	.....	5.50	5.35	.....	5.20
10	6.30	6.00	4.90	4.90	5.20	.....	.....	.....	5.40	5.30	.....	5.10
11	6.30	6.00	4.90	4.90	5.20	.....	.....	.....	5.30	5.30	.....	5.00
12	6.30	6.00	4.90	4.90	5.10	.....	5.05	.....	5.20	5.20	.....	4.90
13	6.30	6.00	4.90	4.90	.....	.....	.....	.....	5.10	5.20	.....	4.75
14	6.30	6.05	4.90	4.90	.....	.....	.....	.....	.....	5.15	.....	4.70
15	6.30	6.20	4.90	4.90	.....	.....	.....	.....	.....	4.95	.....	4.70
16	6.30	6.30	4.90	4.90	.....	.....	.....	.....	.....	4.90	.....	.....
17	6.30	6.25	4.90	4.90	.....	.....	.....	.....	.....	4.90	.....	.....
18	6.30	6.20	4.90	6.80	.....	.....	.....	.....	.....	4.90	.....	.....
19	6.30	6.20	4.90	6.90	.....	.....	.....	.....	.....	.....	.....	.....
20	6.30	6.20	4.90	6.90	.....	.....	.....	.....	.....	.....	.....	.....
21	6.30	6.10	4.90	6.95	.....	.....	.....	.....	.....	.....	.....	5.30
22	6.30	5.95	4.90	6.65	.....	.....	.....	.....	.....	.....	.....	5.90
23	6.30	5.75	4.90	6.60	.....	.....	.....	.....	.....	.....	.....	5.65
24	6.30	5.50	4.90	6.55	.....	.....	.....	.....	.....	.....	.....	5.45
25	6.30	5.30	4.90	6.80	.....	.....	.....	.....	.....	.....	.....	5.35
26	6.30	5.05	4.90	7.30	.....	.....	.....	.....	7.60	.....	5.30	5.15
27	6.30	5.00	4.90	7.50	.....	.....	.....	6.30	7.85	.....	5.30	5.05
28	6.30	5.00	4.90	7.25	.....	.....	.....	7.75	7.10	.....	5.30	4.95
29	6.30	.....	4.90	6.70	.....	.....	.....	9.95	6.55	.....	5.30	4.75
30	6.30	.....	4.90	6.30	.....	.....	.....	9.40	6.35	.....	5.30	4.70
31	6.30	.....	4.90	.....	.....	.....	.....	9.05	.....	.....	.....	4.70

[a] On the days for which no gage heights are given the river was dry.

Estimated monthly discharge of the Rio Grande near El Paso, Tex.

[Drainage area, 30,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	140	130	135	8,291	0.0045	0.0052
February	160	30	104	5,772	.0035	.0036
March	20	10	10	635	.0003	.0003
April	540	10	133	7,904	.0044	.0049
May	75	0	9	526	.0003	.0003
June	135	0	5	307	.0002	.0002
July	10	0	0	20	.0000	.0000
August	2,140	0	236	14,499	.0079	.0091
September	860	0	156	9,313	.0052	.0058
October	115	0	23	1,428	.0008	.0009
November	30	0	5	298	.0002	.0002
December	115	0	29	1,775	.0010	.0012
The year	2,140	0	70	50,768	.0024	.0317

RIO GRANDE NEAR SAN MARCIAL, N. MEX.

This station is located about one-half mile south of San Marcial, N. Mex., at the bridge of the Atchison, Topeka and Santa Fe Railroad. The original gage was established by Arthur P. Davis on January 29, 1895. The observer was Bert Halseth, San Marcial, N. Mex., whose house is about one-half mile distant. The gage was of hard pine timber, 9 by 5 inches by 25 feet, anchored and bolted to the east end of the second pier from the south. It was inclined and painted white. The distance between the footmarks was 1.6 feet. The 13-foot mark was level with the extension of the pier, to which the gage was anchored. The 15-foot mark was level with the top of the capstone on which the bridge truss rests. Measurements were made from the same bridge. On August 8, 1889, a station was established near San Marcial, and a measurement was made which gave a discharge of 19 second-feet. Soon after this date, however, the river gage was destroyed and the locality was abandoned until 1895.

In 1896 the inclined gage was carried away and a wire gage was put in its place. The wire gage is attached to the guard rail of the bridge, south span, lower side. Bench mark No. 1 is the top of the capstone on which the bridge truss rests, and is at an elevation of 15 feet above gage datum; bench mark No. 2 is the top of the extension of the pier to which the old vertical gage was fastened, and is at an elevation of 13 feet above gage datum. The wire gage has been abandoned and the gage heights are now measured with a graduated rod from the deck of th bridge but using the old gage datum. The channel is

sandy and shifting. A number of bridge piers interfere with the current to a certain extent, but not with the observed gage heights. They sometimes affect the discharge measurements.

Discharge measurements of the Rio Grande near San Marcial, N. Mex.

[Made by W. W. Sentman and J. R. Nisbet.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 1	7.2	389	April 24	8.3	1,441
January 3	7.15	348	April 26	7.9	763
January 6	7.3	469	April 28	7.7	575
January 27	7.4	238	April 30	7.9	583
January 30	7.3	291	May 2	7.7	378
February 3	7.4	383	May 8	7.4	221
February 5	7.4	425	May 10	7.5	250
February 7	7.45	331	May 12	7.6	281
February 10	7.6	340	May 14	7.7	298
February 12	7.4	358	May 16	8.1	906
February 14	7.4	266	May 20	7.8	470
February 17	7.5	296	May 22	7.5	325
February 20	7.4	279	May 24	7.4	232
February 22	7.4	294	May 26	7.1	105
February 24	7.4	298	May 28	6.6	33
February 28	7.4	222	May 29	8.2	1,473
March 4	7.3	218	May 31	7.7	773
March 6	7.3	195	June 3	7.4	451
March 8	7.3	178	June 5	7.4	363
March 10	7.1	157	June 7	7.2	191
March 12	6.9	84	June 9	7.1	119
March 15	6.5	49	June 12 [a]	6.7	42
March 17	6.8	88	August 12	7.35	198
March 19	7.1	132	August 14	6.9	51
March 21	7.0	84	August 16	7.5	243
March 27	7.1	113	August 18	7.25	82
March 29	7.2	113	August 27	8.25	2,385
March 31	7.1	115	August 31	6.6	321
April 2	7.0	99	September 2	6.5	89
April 4	6.9	69	September 4	5.4	29
April 7	6.4	23	September 6	5.0	10
April 9	5.8	2	September 23	8.4	2,418
April 12	8.1	841	September 26	6.3	497
April 14	8.3	1,275	September 28	5.9	142
April 16	8.3	1,307	October 3	5.2	25
April 18	8.3	1,157	October 6	4.9	19
April 22	8.2	912	October 9	5.0	17

[a] River dry the balance of the month and during July.

Discharge measurements of the Rio Grande near San Marcial, N. Mex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
October 12	4.9	14	November 30	6.0	156
October 15	4.8	7	December 3	6.0	104
October 30	4.9	12	December 6	6.1	134
November 2	5.0	13	December 9	6.2	142
November 4	5.0	18	December 14	6.3	151
November 7	5.1	17	December 17	6.7	244
November 10	5.1	18	December 20	6.3	80
November 13	5.2	31	December 22	5.9	60
November 16	6.4	202	December 25	6.5	289
November 20	6.0	117	December 28	6.4	258
November 24	5.9	122	December 31	6.25	186
November 28	5.95	158			

Daily gage height, in feet, of the Rio Grande near San Marcial, N. Mex.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.25	7.35	7.35	7.10	7.80	7.50	.....	.....	6.35	5.35	5.00	6.00
2	7.15	7.30	7.50	7.00	7.65	7.40	.....	.....	6.40	5.70	5.00	6.00
3	7.25	7.35	7.45	6.90	7.60	7.35	.....	.....	5.70	5.25	5.00	6.00
4	7.35	7.45	7.35	6.85	7.55	7.40	.....	.....	5.45	5.05	5.00	5.60
5	7.35	7.40	7.35	6.70	7.35	7.40	.....	.....	5.15	5.00	5.00	5.70
6	7.30	7.50	7.30	6.55	7.45	7.30	.....	.....	5.05	4.90	5.00	6.15
7	7.30	7.45	7.30	6.40	7.40	7.20	.....	.....	.....	4.80	5.10	6.15
8	7.30	7.55	7.30	6.20	7.40	7.20	.....	.....	.....	5.15	5.10	6.15
9	7.15	7.50	7.20	5.80	7.65	7.15	.....	.....	.....	5.10	5.10	6.20
10	7.05	7.60	7.20	.....	7.55	7.05	.....	.....	.....	5.00	5.10	6.25
11	7.10	7.40	7.05	.....	7.50	6.85	.....	.....	.....	4.95	5.10	6.30
12	7.10	7.45	6.90	8.20	7.60	6.70	.....	7.00	.....	4.90	5.10	6.30
13	7.35	7.35	6.80	8.20	7.70	6.55	.....	7.05	.....	4.90	5.20	6.30
14	7.40	7.40	6.70	8.35	7.70	.....	.....	7.80	.....	4.90	5.20	6.30
15	7.40	7.40	6.50	8.35	7.75	.....	.....	8.50	.....	4.80	5.80	6.50
16	7.35	7.50	6.50	8.40	8.50	.....	.....	7.55	.....	4.80	6.30	6.90
17	7.40	7.50	6.95	8.25	8.05	.....	.....	7.25	.....	.....	6.20	6.70
18	7.40	7.55	7.10	8.30	7.80	.....	.....	7.20	.....	.....	6.05	6.60
19	7.30	7.50	7.20	8.00	7.80	.....	.....	6.90	.....	.....	6.00	6.40
20	7.35	7.45	7.20	8.15	7.75	.....	.....	6.65	.....	.....	6.00	6.30
21	7.30	7.35	7.10	8.20	7.65	.....	.....	.....	.....	.....	5.95	5.95
22	7.30	7.40	6.95	8.30	7.55	.....	.....	.....	6.20	.....	5.90	5.95
23	7.35	7.40	6.75	8.45	7.45	.....	.....	.....	8.45	.....	5.90	6.45
24	7.35	7.45	6.60	8.30	7.35	.....	.....	7.25	7.85	4.80	5.85	6.55
25	7.40	7.40	6.60	8.10	7.15	.....	.....	9.05	6.70	4.80	5.80	6.50
26	7.30	7.40	6.65	7.90	7.00	.....	.....	11.10	6.25	4.80	5.70	6.40
27	7.40	7.40	7.20	7.90	6.95	.....	.....	8.45	6.15	4.80	5.70	6.45
28	7.35	7.40	7.30	7.70	6.65	.....	.....	7.85	6.00	4.80	5.80	6.50
29	7.30	.....	7.25	7.85	8.20	.....	.....	7.45	5.85	4.90	6.00	6.70
30	7.35	.....	7.25	7.85	8.35	.....	.....	7.40	5.55	4.90	6.00	6.45
31	7.35	.....	7.20	.....	7.65	.....	.....	6.65	.....	4.90	.....	6.40

[a] There was no flow on days for which no gage heights are given.

Estimated monthly discharge of the Rio Grande near San Marcial, N. Mex.

[Drainage area, 28,067 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	500	300	370	22,731	0.0132	0.0152
February	480	220	314	17,435	.0112	.0117
March	250	50	129	7,954	.0046	.0053
April	1,650	0	674	40,106	.0240	.0268
May	1,710	35	436	26,787	.0155	.0179
June	560	0	108	6,407	.0038	.0042
July	[a] 0	[a] 0	[a] 0	[a] 0	[a] 0	[a] 0
August	10,500	0	800	49,210	.0285	.0329
September	2,460	0	224	13,349	.0080	.0089
October	75	0	13	823	.0005	.0006
November	180	15	78	4,641	.0028	.0031
December	350	65	184	11,286	.0066	.0076
The year	10,500	0	278	200,729	.0099	.1342

[a] River dry June 14 to August 11, inclusive.

RIO GRANDE AT WATER TANK, NEAR RIO GRANDE, OR BUCKMAN, N. MEX.

Three miles below Embudo the river emerges into Espanola Valley, through which it continues for a few miles and then enters White Rock Canyon, flowing through that canyon for 30 miles. At the lower end of this canyon the river emerges into Albuquerque Valley, and so continues down to about Socorro. This valley averages from 1 to 3 miles in width, and has been irrigated for a great many years by the Mexican settlers. Their primitive methods of irrigation are very wasteful of the waters, so that the duty of water in this section, about 17 acres per second-foot, is not as high as it might be. During the last few years, however, a number of important and modern irrigation systems have been planned and built in the vicinity of Albuquerque. The gaging station, established February 2, 1895, is located about one-fourth of a mile above Water Tank, a section on the Santa Fe Southern Railroad, below Espanola. It was established by Arthur P. Davis and P. E. Harroun on February 1, 1895. The observer is Thomas Dupre, section foreman, whose house is distant from the gaging station about one-fourth of a mile. The inclined portion of the gage is marked from 3.5 feet to 10.6 feet; the vertical portion from 10.6 feet to 16 feet. The inclined part of the gage is braced with wood and anchored with stones. The upper part is set in

the ground, leaning against a huge boulder, and is held in that position by wire, well tightened. The highest point of the boulder is marked with a black cross, and is 6.815 feet above the 11-foot mark. Measurement was made from gaging box suspended from cable placed across just above the gage. The channel is sandy and shifting.

Discharge measurements of the Rio Grande near Rio Grande, N. Mex.

[Made by P. E. Harroun and O. B. Powell.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 23	5.0	484	July 14	3.8	93
February 12	5.05	485	July 17	3.8	110
March 31	5.3	518	July 21	5.0	419
April 3	5.3	519	July 24	5.0	416
April 7	6.7	1,243	July 28	4.3	208
April 10	7.5	1,744	July 31	4.0	112
April 14	7.9	2,252	August 4	4.2	148
April 17	7.5	1,952	August 7	4.7	233
April 22	7.6	2,190	August 11	6.15	[a] 2,009
April 25	6.5	1,333	August 14	4.6	241
April 28	6.6	1,403	August 18	4.3	172
May 2	6.5	1,164	August 21	3.9	106
May 5	6.6	1,271	August 25	8.1	2,853
May 8	6.3	1,109	August 28	6.0	848
May 12	6.7	1,267	September 1	4.5	232
May 15	6.7	1,391	September 4	4.1	150
May 19	6.1	895	September 8	4.1	139
May 23	5.6	633	September 11	3.8	85
May 26	5.2	516	September 15	4.0	117
May 28	7.4	1,877	September 18	3.8	122
May 30	6.6	1,561	September 21	10.7	6,592
June 2	6.6	1,449	September 25	4.7	309
June 6	5.8	857	September 29	4.7	250
June 9	5.5	672	October 2	4.6	255
June 12	5.0	421	October 6	4.7	325
June 16	4.7	332	October 9	4.7	276
June 19	4.3	180	October 13	4.7	265
June 23	4.0	123	October 16	4.7	294
June 27	3.8	85	October 20	4.7	276
June 30	3.6	71	October 23	4.7	268
July 3	3.5	62	October 27	4.6	266
July 7	3.6	78	October 30	4.7	285
July 10	3.8	125	November 3	4.7	282

[a] Abnormally large.

Discharge measurements of the Rio Grande near Rio Grande, N. Mex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
November 6	4.7	264	December 4	4.4	245
November 10	4.7	261	December 8	4.8	347
November 13	5.0	403	December 11	4.8	320
November 17	4.7	278	December 15	4.8	335
November 21	4.7	295	December 18	4.4	264
November 24	4.9	399	December 22	4.6	297
November 27	4.6	273	December 26	4.7	337
December 1	4.5	276	December 29	4.7	282

Daily gage height, in feet, of the Rio Grande near Rio Grande, N. Mex.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.00	4.95	5.15	5.25	6.40	6.70	3.55	5.10	4.45	4.65	4.70	[illegible]
2	5.05	4.95	5.10	5.35	6.40	6.70	3.60	4.25	4.40	4.60	4.70	[illegible]
3	5.00	4.95	5.10	5.50	6.40	6.45	3.55	4.10	4.30	4.70	4.70	[illegible]
4	5.10	4.90	5.10	5.50	6.50	6.15	3.50	4.05	4.10	4.70	4.60	[illegible]
5	5.10	4.95	5.10	5.55	6.50	6.00	3.50	5.60	4.10	4.80	4.65	[illegible]
6	5.10	4.95	5.00	6.05	6.35	5.75	3.55	6.35	3.95	4.70	4.65	[illegible]
7	5.05	4.95	5.00	6.20	6.35	5.70	3.55	4.70	4.15	4.70	4.70	[illegible]
8	5.05	5.05	5.05	6.95	6.40	5.60	3.55	4.80	4.15	4.65	4.70	[illegible]
9	5.05	5.05	5.05	7.55	6.55	5.45	3.90	4.50	3.95	4.70	4.70	[illegible]
10	5.10	5.05	5.25	7.80	6.55	5.15	4.75	4.25	3.90	4.70	4.70	[illegible]
11	5.10	5.05	5.55	8.05	6.75	5.05	3.65	5.90	3.80	4.70	4.60	[illegible]
12	5.00	5.05	5.55	8.45	7.20	4.95	3.70	5.30	3.90	4.70	5.05	[illegible]
13	5.00	5.05	5.40	8.10	7.35	5.15	3.80	4.70	3.90	4.65	5.00	[illegible]
14	5.05	5.00	5.40	7.95	6.90	4.95	3.65	4.75	3.90	4.65	5.00	[illegible]
15	5.05	5.00	5.25	7.55	6.65	4.75	3.60	4.50	3.95	4.70	4.90	[illegible]
16	5.05	5.00	5.20	7.15	6.45	4.65	3.50	4.25	3.85	4.70	4.85	[illegible]
17	5.00	5.05	5.20	7.55	6.25	4.50	4.25	4.50	3.85	4.70	4.70	[illegible]
18	5.15	5.15	5.10	7.65	6.20	4.35	4.50	4.30	3.90	4.70	4.70	[illegible]
19	5.10	5.10	5.45	7.65	6.20	4.30	6.15	4.15	4.05	4.60	4.70	[illegible]
20	5.10	5.15	5.60	7.90	6.05	4.15	7.80	4.00	6.20	4.70	4.70	[illegible]
21	5.10	5.05	5.60	7.80	5.95	4.10	5.20	3.90	10.60	4.70	4.70	[illegible]
22	5.00	5.15	5.75	7.50	5.85	4.00	5.45	4.90	7.35	4.70	4.80	[illegible]
23	4.95	5.20	5.65	6.75	5.50	3.95	4.35	5.55	5.80	4.70	4.90	[illegible]
24	5.00	5.20	5.55	6.60	5.30	3.90	4.55	6.35	4.90	4.70	4.90	[illegible]
25	4.95	5.20	5.40	6.60	5.25	3.95	4.45	7.60	4.80	4.60	4.90	[illegible]
26	5.00	5.35	5.35	6.60	5.20	3.85	4.45	7.25	4.75	4.60	4.70	[illegible]
27	4.75	5.35	5.40	6.55	7.80	3.75	4.35	6.15	4.60	4.60	4.70	[illegible]
28	4.80	5.25	5.25	6.50	7.25	3.60	4.30	5.60	4.60	4.60	4.65	[illegible]
29	4.95	.....	5.35	6.45	7.05	3.60	4.25	5.15	4.70	4.65	4.60	[illegible]
30	5.00	.....	5.30	6.45	6.65	3.60	4.15	4.95	4.65	4.70	4.60	[illegible]
31	4.95	.....	5.30	.....	6.65	.....	4.05	4.70	.....	4.70	.....	[illegible]

Estimated monthly discharge of the Rio Grande near Rio Grande, N. Mex.

[Drainage area, 14,050 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	495	455	482	29,643	0.034	0.039
February	540	475	489	27,183	.035	.036
March	735	480	548	33,709	.039	.045
April	3,200	510	1,640	97,577	.117	.131
May	2,230	520	1,196	73,567	.085	.098
June	1,530	70	474	28,215	.034	.038
July	2,200	60	272	16,730	.019	.022
August	2,300	105	556	34,165	.040	.046
September	6,460	85	484	28,790	.034	.038
October	345	255	279	17,157	.020	.023
November	420	250	309	18,386	.022	.025
December	440	200	313	19,220	.022	.025
The year	6,460	60	587	424,342	.042	.566

RIO GRANDE AT EMBUDO, N. MEX.

Embudo is a railroad station on the Denver and Rio Grande Railroad, in Rio Arriba County. The station is in a narrow canyon above the head of the valley in which Espanola and other towns are located, and in which the river Chama joins the Rio Grande. In November, 1888, an examination was made along the main stream for the purpose of selecting a point at which the total discharge of the Rio Grande entering New Mexico could be ascertained. Coming from Colorado southward, this is the first point at which the railroad reaches the river, and for this reason it was finally determined to establish a river station here. Measurements were begun at the rocky narrows, about a mile above the railroad station, but in the spring of 1889 the observations were transferred to a point directly behind the railroad station, for convenience of the observer and consequent reduction of expense. The inclined gage, constructed at that time, is made of scantling, 4 by 4 inches, spiked to posts set firmly in the ground. It is on the right hand side of the river, at a place where the slopes are very gentle, and therefore is of considerable length in order to reach out to the low-water channel. It is graduated from about 7.30 feet, the low-water mark, up to 16 feet. The point 3.50 would correspond approximately to the deepest part of the section. The gage is about 75 feet above the cable and is in three parts with different slopes. The cable is five-

eighths-inch wire, with 19 steel strands. It is fastened to a cedar tree on the left-hand side and to sand anchors on the right. Measurements were originally made from a boat held by traveling pulleys running on the cable. The boat being washed away by flood, later measurements were made from a box suspended from the cable.

Bench mark No. 1 is on a rock near the end of the cable, on the left-hand bank, marked "B. M." with white paint. It is 20.66 feet above zero of the gage. Bench mark No. 2 is on a rock about 100 feet above the cable, on the left bank of the river, and is marked "B. M." with white paint. It is 18.79 feet above datum. Bench mark No. 3 is a notch cut in the southeast corner of the station house, about 2 feet above the level of the platform, and is 30.48 feet above datum.

Discharge measurements of the Rio Grande at Embudo, N. Mex.

[Made by P. E. Harroun and O. B. Powell.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
January 21	7.5	386	July 1	6.8	147
February 10	7.6	422	July 4	6.8	140
March 28	7.8	410	July 8	6.8	137
April 9	8.2	631	July 12	6.8	140
April 12	8.5	773	July 15	6.8	144
April 15	8.4	771	July 19	6.9	150
April 18	8.3	667	July 22	7.1	192
April 23	8.4	741	July 25	6.8	154
April 26	8.1	604	July 29	6.9	164
April 29	8.1	632	August 1	6.8	158
May 3	8.3	715	August 5	6.8	156
May 6	8.5	849	August 8	7.2	235
May 9	8.6	900	August 13	7.0	191
May 13	8.8	1,099	August 16	6.9	16[illegible]
May 16	8.5	901	August 19	6.8	152
May 20	8.3	814	August 23	7.0	176
May 24	7.8	471	August 26	8.2	785
May 27	8.1	611	August 29	7.1	227
May 31	8.7	990	September 2	7.0	198
June 4	8.6	917	September 6	6.9	166
June 7	8.3	697	September 9	6.9	164
June 10	7.8	450	September 12	6.9	167
June 13	7.5	364	September 16	6.9	165
June 17	7.2	240	September 19	6.9	160
June 21	7.0	196	September 23	7.2	250
June 25	6.9	179	September 26	7.1	223
June 28	6.9	152	September 30	7.1	229

Discharge measurements of the Rio Grande at Embudo, N. Mex.—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1902.	*Feet.*	*Second-feet.*	1902.	*Feet.*	*Second-feet.*
October 2	7.1	217	November 18	7.1	225
October 6	7.2	217	November 21	7.3	235
October 10	7.2	227	November 25	7.3	247
October 14	7.2	238	November 28	7.1	218
October 17	7.2	229	December 2	7.2	252
October 21	7.2	228	December 5	7.1	225
October 24	7.2	240	December 9	7.2	246
October 28	7.2	230	December 12	7.3	246
October 31	7.2	217	December 16	7.3	244
November 4	7.2	218	December 20	7.5	316
November 7	7.2	219	December 23	7.3	268
November 11	7.2	226	December 27	7.3	266
November 14	7.2	228	December 31	7.2	249

Daily gage height, in feet, of the Rio Grande at Embudo, N. Mex.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.60	7.40	8.00	7.70	8.10	9.10	6.80	6.80	7.00	7.10	7.20	7.20
2	7.70	7.70	7.90	7.75	8.20	9.00	6.80	6.80	7.05	7.10	7.20	7.20
3	7.65	7.50	8.00	7.80	8.30	8.85	6.80	6.80	7.00	7.25	7.20	7.20
4	7.70	7.50	8.00	7.80	8.40	8.65	6.80	7.20	7.00	7.20	7.20	7.15
5	7.65	7.55	7.85	7.80	8.40	8.55	6.80	7.40	7.00	7.20	7.20	7.15
6	7.65	7.55	7.85	7.85	8.45	8.45	6.80	7.60	6.95	7.20	7.20	7.20
7	7.65	7.60	7.85	7.90	8.50	8.25	6.80	7.00	6.90	7.20	7.20	7.25
8	7.70	7.55	7.85	8.05	8.50	8.10	6.80	7.20	6.90	7.20	7.20	7.25
9	7.70	7.60	8.05	8.25	8.55	7.90	6.80	7.05	6.90	7.20	7.20	7.20
10	7.70	7.60	8.10	8.30	8.60	7.80	6.80	6.90	6.90	7.20	7.20	7.20
11	7.65	7.60	8.15	8.55	8.75	7.70	6.80	7.65	6.90	7.20	7.25	7.20
12	7.60	7.65	8.00	8.55	8.80	7.60	6.80	7.15	6.90	7.20	7.50	7.30
13	7.65	7.70	7.90	8.55	8.80	7.55	6.80	7.05	6.90	7.20	7.25	7.30
14	7.55	7.60	7.95	8.50	8.80	7.35	6.80	7.00	6.90	7.20	7.25	7.30
15	7.65	7.65	7.90	8.40	8.70	7.25	6.80	7.00	6.90	7.20	7.20	7.20
16	7.65	7.65	7.80	8.40	8.55	7.20	6.80	6.90	6.90	7.20	7.20	7.20
17	7.65	7.75	7.80	8.40	8.40	7.15	6.90	7.05	6.90	7.20	7.20	7.20
18	7.60	7.75	7.70	8.30	8.40	7.10	6.90	6.95	6.90	7.20	7.10	7.20
19	7.60	7.80	8.00	8.40	8.35	7.05	6.90	6.85	6.95	7.20	7.15	7.50
20	7.70	7.70	8.20	8.40	8.25	7.00	7.35	6.80	7.05	7.20	7.20	7.50
21	7.60	7.90	8.10	8.50	8.15	7.00	7.30	6.85	8.75	7.20	7.25	7.40
22	7.55	7.85	8.10	8.45	8.05	7.00	7.00	7.00	7.40	7.20	7.30	7.45
23	7.50	7.85	8.00	8.45	7.95	7.00	6.90	7.15	7.25	7.30	7.30	7.35
24	7.60	7.85	7.95	8.35	7.80	6.90	6.85	7.15	7.15	7.20	7.35	7.45
25	7.60	7.90	7.95	8.25	7.70	6.90	6.90	7.50	7.10	7.20	7.25	7.45
26	7.60	8.00	7.85	8.10	7.75	6.90	6.90	8.25	7.10	7.25	7.10	7.35
27	7.50	8.05	7.80	8.10	8.00	6.90	6.90	7.45	7.10	7.30	7.10	7.35
28	7.60	8.00	7.80	8.10	8.20	6.90	6.90	7.20	7.10	7.25	7.10	7.40
29	7.60	.....	7.95	8.10	8.35	6.80	6.90	7.10	7.10	7.20	7.15	7.35
30	7.60	.....	7.85	8.10	8.55	6.80	6.90	7.10	7.10	7.20	7.20	7.30
31	7.50	.....	7.70	.....	8.80	.....	6.80	7.00	.....	7.20	.....	7.30

Estimated monthly discharge of the Rio Grande at Embudo, N. Mex.

[Drainage area, 10,090 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	460	390	430	26,420	0.043	0.050
February	585	360	462	25,676	.046	.048
March	630	410	532	32,698	.053	.061
April	800	450	661	39,352	.066	.074
May	1,100	420	798	49,061	.079	.091
June	1,360	130	440	26,202	.044	.049
July	280	140	158	9,719	.016	.018
August	820	150	246	15,154	.024	.028
September	1,050	165	228	13,587	.023	.026
October	260	215	231	14,182	.023	.027
November	310	220	231	13,736	.023	.026
December	315	240	264	16,245	.026	.030
The year	1,360	130	390	282,032	.039	.528

RIO GRANDE NEAR CENICERO, COLO.

This station was located on June 28, 1899, by A. L. Fellows. It is at the State bridge across the Rio Grande, at a point near the Colorado-New Mexico State line and about 4 miles west of Eastdale, Colo. The station is favorably located for the purpose, the cross section being fairly uniform, the channel regular and not liable to overflow.

There are two gage rods, one for high water and the other for low water. The high-water rod is a 2 by 6 inch timber attached to the west side of the central downstream cylinder of the bridge. The low-water rod is a scale, marked in feet and tenths, on the perpendicular face of a large bowlder about a hundred yards below the bridge. The channel is in most respects an excellent one. The bed consists of bowlders and rock, and is subject to little change; the banks are high and are not subject to overflow. Gagings can be made at the bridge, but during low water they are usually made by wading. On June 22, 1900, both gages were referred to a bench mark consisting of a chiseled point marked "B. M." on the face of the lava bluff under the west end of the bridge, 7.42 feet above gage datum. The station is an extremely important one, giving, as it does, the discharge of the river at the Colorado State line, including practically all of the Colorado drainage.

Roman Mondragon, who keeps a store at the west end of the bridge, has kept the records during the last year.

The following measurement was made in 1902 by A. L. Fellows:

July 9: Gage height, 0.60 feet; discharge, 6 second-feet.

Daily gage height, in feet, of the Rio Grande near Cenicero, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.80	2.10	2.40	1.50	1.40	1.80	0.80	0.80	0.70	0.90	0.90	0.90
2	1.80	2.10	2.50	1.60	1.60	1.70	.80	.80	.70	.90	.90	.90
3	1.80	2.00	2.60	1.60	1.70	1.60	.80	.80	.70	.90	.90	.90
4	1.80	2.00	2.60	1.60	1.80	1.50	.80	.80	.70	.90	.90	.90
5	1.80	2.00	3.00	1.60	1.90	1.50	.80	.80	.70	.90	.90	.90
6	1.80	2.00	3.00	1.60	1.90	1.40	.80	.80	.70	.90	.90	.90
7	1.80	2.00	2.60	1.60	1.90	1.40	.80	.80	.70	.90	.90	.90
8	1.80	2.00	2.50	1.70	1.90	1.40	.80	.80	.80	.90	.90	.90
9	1.80	2.00	2.40	1.70	1.90	1.40	.80	.80	.80	1.00	.80	.90
10	1.80	2.00	1.70	1.80	1.90	1.30	.80	.80	.80	1.00	.80	1.00
11	1.80	2.00	1.70	1.80	1.90	1.30	.80	.80	.80	1.00	.80	1.00
12	1.80	2.00	1.70	1.90	1.90	1.30	.80	.80	.90	1.00	.90	1.00
13	1.80	2.00	1.70	1.90	1.90	1.30	.80	.80	.90	1.00	.90	1.00
14	1.80	2.10	1.70	1.90	1.90	1.30	.80	.80	.90	1.00	.90	1.00
15	1.90	2.20	1.70	1.80	2.00	1.20	.80	.80	.90	.90	.90	1.00
16	1.90	2.20	1.70	1.80	2.00	1.20	.80	.80	.90	.90	.90	1.00
17	1.90	2.20	1.90	1.80	1.90	1.20	.80	.70	.90	.90	.90	1.00
18	1.90	2.30	1.70	1.70	1.90	1.20	.80	.70	.90	.90	.90	1.00
19	1.90	2.30	1.70	1.70	1.90	1.20	.80	.70	.90	.90	.90	1.00
20	1.90	2.40	1.60	1.70	1.90	1.20	.80	.70	.90	.90	.90	1.00
21	1.90	2.40	1.60	1.70	1.90	1.20	.80	.60	.90	.80	.90	1.00
22	2.10	2.40	1.60	1.70	1.90	1.10	.80	.60	.90	.80	.90	1.00
23	2.10	2.40	1.60	1.70	1.90	1.10	.80	.60	.90	.80	.90	1.00
24	2.10	2.40	1.60	1.90	1.90	1.10	.80	.60	.90	.80	.90	1.00
25	2.10	2.40	1.60	1.50	1.90	1.00	.80	.60	.90	.90	.90	1.00
26	2.10	2.40	1.90	1.50	2.00	1.00	.80	.60	.90	.90	.90	1.00
27	2.10	2.40	1.70	1.50	2.00	.90	.80	.70	.90	.90	.90	1.00
28	2.10	2.40	1.60	1.50	2.00	.90	.80	.70	.90	.90	.90	.80
29	2.10	.....	1.60	1.50	2.00	.80	.80	.70	.90	.90	.90	.70
30	2.10	.....	1.60	1.50	1.90	.80	.80	.70	.90	.90	.90	.70
31	2.10	.....	1.50	.....	1.80	.....	.80	.70	.....	.90	.....	.80

Rating table for the Rio Grande near Cenicero, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	6	1.8	414	3.0	1,494	4.2	2,574
0.8	22	2.0	594	3.2	1,674	4.4	2,754
1.0	44	2.2	774	3.4	1,854	4.6	2,934
1.2	82	2.4	954	3.6	2,034	4.8	3,114
1.4	142	2.6	1,134	3.8	2,214	5.0	3,294
1.6	244	2.8	1,314	4.0	2,394		

Estimated monthly discharge of the Rio Grande near Cenicero, Colo.

[Drainage area, 7,695 square miles.]

Month.	Discharge in second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
January	684	414	521	32,035	0.0677	0.078
February	954	594	758	42,097	.0985	.103
March	1,494	185	549	33,757	.0713	.082
April	504	185	315	18,744	.0409	.046
May	594	142	490	30,129	.0637	.074
June	414	22	114	6,783	.0148	.017
July	22	22	22	1,353	.0029	.003
August	22	6	17	1,045	.0022	.003
September	31	14	26	1,547	.0034	.004
October	44	22	32	1,968	.0042	.005
November	31	22	30	1,785	.0039	.004
December	44	14	37	2,275	.0048	.006
The year	1,494	6	243	173,518	.0315	.425

RIO GRANDE NEAR DEL NORTE, COLO.

Measurements and observations were first begun in the vicinity of Del Norte in 1889 by George T. Quinby. The object of the measurements was to obtain the flow of the river before water was diverted for the agricultural region of the San Luis Valley, and, by a comparison of this with the figures obtained at Embudo, to acquire data as to the effect of the numerous ditches taking out water between the two points. The river 25 miles above Del Norte flows out of the canyon at Wagon Wheel Gap. Little water, however, is diverted until the edge of the San Luis Valley is reached, the largest canal heading near the town of Del Norte. During freshets the river divides into a number of channels, making it difficult to obtain measurements near town. In order to avoid the expense of establishing a station during time of high water, the first measurements—those about June 1—were made from several bridges crossing the numerous branches. The results were not wholly satisfactory, and on June 25 a station was established above the branches. Later a locality about 2 miles farther up was chosen.

The station is about 2 miles west of the town of Del Norte, above the main canal taking water from the Rio Grande and is above all the irrigating ditches of importance. The river flows in one channel about 175 feet wide and of very regular section. The banks on each side are steep, and the water is reported never to overflow. The

course of the stream is straight for several hundred yards both above and below the section. An inclined gage is set, at an angle of about 30° to the horizontal, on the left bank, and is referred to bench marks. As noted on October 10, 1891, No. 1 is a large nail in the root of a tree 15 feet northwest of the end of the cable on left bank of river. Bench mark No. 2 is a large nail in the root of a tree 25 feet southwest of the end of the inclined gage. Both bench marks are 7.54 feet above the datum of the gage.

On June 16, 1900, the gage rod was connected with an iron bench mark of the United States Geological Survey, set in the ground about 25 feet south of the rod, the zero of the rod being 9.25 feet below the bench mark

Gagings were first made from a flatboat, 4 feet wide and 14 feet long, attached by rope and tackle to a five-eights-inch wire cable fastened to a large cottonwood tree on the left bank, and to a sand anchor on the right bank. They are now made by means of a car which travels across the river along a steel cable, the distance being marked on a tag wire. The channel is excellent, the water, although falling rapidly, seldom scouring, and the bed, therefore, remaining practically the same from year to year. The bed of the channel is covered with small bowlders and the sides, although not high, have never been known to overflow. The observer is J. S. Regan, who has kept the records regularly ever since the station was established.

The following discharge measurements were made during 1902 by A. L. Fellows and J. E. Field:

April 24: Gage height, 1.90 feet; discharge, 493 second-feet.
July 8: Gage height, 1.31 feet; discharge, 210 second-feet.

Daily gage height, in feet, of the Rio Grande near Del Norte, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.68	1.60	1.68	1.40	2.84	2.66	1.26	1.10	1.34	1.44	1.34	1.84
2	1.62	1.66	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	1.62	1.66	1.60	1.48	3.24	2.44	1.24	1.06	1.30	1.46	1.36	2.00
4	1.62	1.66	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	1.58	1.66	1.60	1.60	2.86	2.34	1.24	1.06	1.24	1.40	1.32	1.92
6	1.58	1.66	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	1.58	1.66	1.60	1.74	2.94	2.30	1.22	1.08	1.20	1.40	1.32	1.96
8	1.58	1.66	1.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	1.58	1.62	1.34	2.00	2.86	2.24	1.26	1.08	1.14	1.48	1.32	1.84
10	1.58	1.62	1.34	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	1.58	1.62	1.34	1.94	2.74	2.10	1.22	1.08	1.12	1.44	1.30	1.80
12	1.52	1.62	1.34	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	1.52	1.62	1.34	1.86	2.72	2.11	1.20	1.14	1.10	1.40	1.38	1.82
14	1.52	1.62	1.34	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	1.52	1.62	1.34	1.84	2.70	1.90	1.16	1.12	1.10	1.38	1.32	1.84
16	1.52	1.70	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	1.52	1.70	1.40	1.82	2.64	1.78	1.10	1.08	1.10	1.34	1.28	1.80
18	1.52	1.70	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	1.56	1.70	1.40	2.04	2.40	1.66	1.20	1.04	1.12	1.30	1.28	1.82

Daily gage height, in feet, of the Rio Grande near Del Norte, Colo.—**Continued.**

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
20	1.56	1.70	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	1.56	1.70	1.40	2.46	2.16	1.50	1.20	1.00	1.40	1.30	1.30	1.50
22	1.56	1.70	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	1.56	1.68	1.26	2.34	2.04	1.50	1.16	1.06	1.52	1.32	1.30	1.7[illegible]
24	1.56	1.68	1.26	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	1.56	1.68	1.26	1.86	2.00	1.42	1.12	1.96	1.52	1.32	1.28	1.5[illegible]
26	1.60	1.68	1.26	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	1.60	1.68	1.26	2.42	2.06	1.34	1.14	1.70	1.54	1.26	1.34	1.8[illegible]
28	1.60	1.68	1.26	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	1.60	.....	1.26	2.46	2.64	1.30	1.14	1.48	1.50	1.22	2.00	1.8[illegible]
30	1.60	.....	1.36	.....	.....	.....	.....	.....	.....	.....	.....	.....
31	1.60	.....	1.36	.....	2.84	.....	1.10	1.40	.....	1.30	.....	1.8[illegible]

Rating table for the Rio Grande near Del Norte, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	69	2.2	812	3.4	1,972	4.6	3,651
1.2	159	2.4	976	3.6	2,218	4.8	3,951
1.4	265	2.6	1,148	3.8	2,480	5.0	4,251
1.6	385	2.8	1,330	4.0	2,758	5.2	4,551
1.8	518	3.0	1,528	4.2	3,051	5.4	4,851
2.0	660	3.2	1,742	4.4	3,351	5.6	5,151

Estimated monthly discharge of the Rio Grande near Del Norte, Colo.

[Drainage area, 1,400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	437	336	381	23,427	0.28	0.32
February	450	385	412	22,811	.29	.29
March	437	189	438	26,932	.31	.36
April	1,027	265	638	37,964	.45	.50
May	1,787	660	1,169	71,879	.84	.97
June	1,201	210	618	36,774	.44	.49
July	189	112	152	9,346	.12	.14
August	631	69	180	11,068	.13	.15
September	348	112	206	12,258	.15	.17
October	312	169	242	14,880	.17	.20
November	660	200	249	14,817	.18	.20
December	660	518	547	33,634	.39	.45
The year	1,787	69	436	315,790	.31	4.24

INDEX.

Page.

Anadarko, Okla., stream measurements at 139-140
Angelina River, Texas, measurements of.. 142
Arkansas City, Kans., stream measurements at 119-120
Arkansas River, measurements of, at Arkansas City, Kans 119-120
measurements of, at Barton, Colo.... 125-126
at Dodge, Kans 122
at Hutchinson, Kans 120-122
at Pueblo, Colo 130-133
at Salida, Colo 136-138
at Syracuse, Kans 123-125
near Canyon, Colo 133-136
near Nepesta, Colo 128-130
near Rockyford, Colo 126-127
stream measurements in basin of 113-138
Arkins, Colo., stream measurements near.. 79-81
Arlington, Nebr., stream measurements near 51-53
Austin, Tex., stream measurements at... 149-153
Bailey, Colo., stream measurements at 94
Ballinger, Tex., stream measurements at.. 152
Barnetts Ford, Tex., stream measurements at 156
Barton, Colo., stream measurements at.. 125-126
Barton Springs, Texas, measurements of. 152-153
Bear Creek, Colorado, measurements of.... 89, 94
Bear Creek, Texas, measurements of 154
Benkleman, Nebr., stream measurements at 113
Big Bend, stream measurements at 94
Big Cypress, Texas, measurements of 140
Big Sandy, Tex., stream measurements near 141
Big Sandy River, Texas, measurements of. 141
Big Sioux River, Nebraska, measurements of 49
Big Sioux River, South Dakota, measurements of 15-16
Big Thompson Creek, Colorado, measurements of 79-81
Bighorn River, Wyoming, measurements of 23-24
Bigspring, Nebr., stream measurements at. 72-73
Blue Creek, Nebraska, measurements of... 93
Blue River, Kansas, measurements of 97-99
Blue River, Nebraska, measurements of ... 112
Bozeman, Mont., stream measurements near 43-45
Brazos River, measurements of, at Richmond, Tex 147
measurements of, at Waco, Tex 143-146
stream measurements in basin of 143-148
Bridgeport, Nebr., stream measurements at. 64-66

Page.

Brush Creek, Wyoming, measurements of.. 94
stream measurements at 94
Buffalo, Wyo., stream measurements at.... 20
Buffalo Creek, Nebraska, measurements of. 92
Buffalo Springs, Colo., stream measurements near 94
Burwell, Nebr., stream measurements at... 92
Calamus Creek, Nebraska, measurements of. 92
Camden, Ark., stream measurements at.... 140
Canadian River, Oklahoma, measurements of 114
Canyon, Colo., stream measurements near. 133-136
Cascade, Mont., stream measurements at .. 35-36
Cenicero, Colo., stream measurements near 192-194
Center Creek, Nebraska, measurements of . 112
Chalk Creek, Colorado, measurements of... 138
Clear Creek, Colorado, measurements of... 84-86
Clear Creek, Texas, measurements of 156
Clear Creek, Wyoming, measurements of .. 20, 94
Cody, Wyo., stream measurements at 21-23
Colorado River, measurements of, at Austin, Tex 149-152
measurements of, at Columbus, Tex.... 149
miscellaneous 152
stream measurements in basin of..... 148-156
Columbus, Nebr., stream measurements at. 55-57
stream measurements near 57-59
Columbus, Tex., stream measurements at.. 149
Comal Creek, Texas, measurements of 157
Comal Spring Creek, Tex., stream measurements at 157
Comfort, Tex., stream measurements at.... 157
Como, Colo., stream measurements at..... 94
Conifer, Colo., stream measurements near.. 94
Corlett, Wyo., stream measurements at 94
Cow Creek, Wyoming, measurements of... 94
Craig, Mont., stream measurements at..... 37
Crete, Nebr., stream measurements at..... 112
Crooked Creek, Nebraska, measurements of. 112
Crow Creek, Montana, measurements of... 50
Cuero, Tex., stream measurements near ... 156
Culbertson, Nebr., stream measurements at 112-113
Deer Park Creek, Colorado, measurements of 94
Del Norte, Colo., stream measurements near 194-196
Denver, Colo., stream measurements at.... 86-88
Devils Gate, Wyo., stream measurements at. 72
Devils River, Texas, measurements of.... 164-165
Devilsriver, Tex., stream measurements at 164-165

Page.

Devilsriver, Tex., stream measurements near 161-163
Dodge, Kans., stream measurements at.... 122
Eagle Pass, Tex., stream measurements at..... 158-160
El Paso, Tex., stream measurements near. 181-183
Elk Creek, Colorado, measurements of..... 94
Elkhorn River, measurements of, near Arlington, Nebr..... 51-53
measurements of, near Norfolk, Nebr. 53-55, 92
Ellsworth, Kans., stream measurements at..... 110-112
Elreno, Okla., stream measurements near.. 114
Embudo, N. Mex., stream measurements at..... 189-192
Enders, Nebr., stream measurements at.... 112
Erskine Falls., Tex., stream measurements near..... 157
Fairplay, Colo., stream measurements at... 94
Forkscreek, Colo., stream measurements at. 84-86
Fourmile Creek, Colorado, measurements of. 94
Fort Hancock, Tex., stream measurements near..... 179-180
Fort McKavett, Tex., stream measurements near..... 156
Fort Niobrara, Nebr., stream measurements at..... 49
Fort Steele, Wyo., stream measurements at. 94
Franklin, Nebr., stream measurements at.. 113
Frenchman River, Nebraska, measurements of..... 112
Gallahers Ferry, Mont., stream measurements at..... 37
Gallatin Ferry, Mont., stream measurements at..... 37
Gallatin River, Montana, measurements of. 38-40
Garland, Ark., stream measurements at ... 140
Grand Encampment Creek, Wyoming, measurements of 94
Granite Canyon, Wyo., stream measurements at..... 94
Greatfalls, Mont., stream measurements at. 37
Guadalupe River, Texas, measurements of, miscellaneous 157
measurements of, near Cuero, Tex..... 156
stream measurements in basin of 156-157
Guernsey, Wyo., stream measurements at.. 68-70
Haigler, Nebr., stream measurements at... 112
Halls Gulch, Colorado, measurements of... 94
Hatton, Wyo., stream measurements near.. 70-71
Havre, Mont., stream measurements at.... 28-31
Hecla, Wyo., stream measurements near... 75-77
Hot Wells, Tex., stream measurements at.. 157
Hutchinson, Kans., stream measurements at..... 120-122
Iola, Kans., stream measurements at 115-116
Ives, Nebr., stream measurements at..... 112-113
Jefferson, Colo., stream measurements at.. 94
Jefferson Creek, Colorado, measurements of 94
Jefferson River, Montana, measurements of. 47-49
Johnsons Fork (Gaudalupe), Texas, measurements of 157
Johnson Fork (Llano), Texas, measurements of..... 154
Jonah, Tex., stream measurements at..... 148
Julesburg, Colo., stream measurements at. 73-75

Page

Junction, Kans., stream measurements at. 100-102
Junction City, Tex., stream measurements near ..... 15[illegible]
Kansas River, Kansas, measurements of.... 95-97
stream measurements in basin of..... 95-11[illegible]
Kearney, Nebr., stream measurements at.. 92
Kearney, Wyo., stream measurements at .. 21
Kersey, Colo., stream measurements at .... 77-7[illegible]
Kimball, Nebr., stream measurements at .. 9[illegible]
Lampasas, Tex., stream measurements at . 14[illegible]
Lampasas, Texas, Sulphur Fork of, measurements of ..... 14[illegible]
Landa Mill Race, Tex., stream measurements at..... 15[illegible]
Langtry, Tex., stream measurements at . 172-17[illegible]
Las Moras Creek, Texas, measurements of . 1[illegible]
Lawrence Fork, Nebraska, measurements of..... 9[illegible]
Lecompton, Kans., stream measurements at..... 95-97
Lexington, Nebr., stream measurements near ..... 59-6[illegible]
Liberty, Kans., stream measurements near ..... 116-11[illegible]
Lincoln, Nebr., stream measurements at... 9[illegible]
Little Laramie River, Wyoming, measurements of..... 70-71
Little River, Texas, measurements of .... 147-14[illegible]
Livingston, Mont., stream measurements near ..... 24-2[illegible]
Llano, Tex., stream measurements near ... 15[illegible]
Llano River, Texas, measurements of.... 153-15[illegible]
Lodgepole Creek, Nebraska, measurements of..... 9[illegible]
Logan, Mont., stream measurements at .... 3[illegible]-4[illegible]
Lonergan Creek, Nebraska, measurements of..... 9[illegible]
Longpine, Nebr., stream measurements at.. 4[illegible]
Longpine Creek, Nebraska, measurements of..... 4[illegible]
Lost Creek, Nebraska, measurements of.... 1[illegible]
Loup River, Nebraska, measurements of... 55-57
Lufkin, Tex., stream measurements near... 14[illegible]
Lyons, Colo., stream measurements at ..... 81-8[illegible]
Madison River, Montana, measurements of. 46-4[illegible]
Malta, Mont., stream measurements at .... 3[illegible]-3[illegible]
Manhattan, Kans., stream measurements near 97-98
Marais des Cygnes River, Kansas, measurements of ..... 14-1[illegible]
Marias River, Montana, measurements of.. 3[illegible]-3[illegible]
Marble Falls, Tex., stream measurements at. 1[illegible]
Margueretta Flume, Texas, measurements of ..... 168-17[illegible]
McCook, Nebr., stream measurements at... [illegible]
Medicine Bow River, Wyoming, measurements of 94
Menardville, Tex., stream measurements at..... 1[illegible]
Michigan Creek, Colorado, measurements of..... 94
Middle Creek, Montana, measurements of.. 43-4[illegible]
Middle Crow Creek, Wyoming, measurements of..... 75-77 [illegible]
Middle Loup River, Nebraska, measurements of..... [illegible]

Page.
Midvale, Mont., stream measurements at.. 34-35
Milk River, measurements of, at Havre, Mont 28-31
measurements of, at Malta, Mont 26-28
Mill Creek, Texas, measurements of 156
Minnichaduza Creek, Nebraska, measurements of 49
Missouri River, measurements of, at Cascade, Mont 35-36
measurements of, at Townsend, Mont.. 36-38
stream measurements in basin of..... 13-50
Mitchell, Nebr., stream measurements at.. 66-68
Moorhead, Tex., stream measurements near 166-168
Morrison, Colo., stream measurements at.. 94
stream measurements near..... 89
Mount Princeton, Colo., stream measurements at..... 138
Musselshell River, Montana, measurements of..... 31-32
Naples, Tex., stream measurements near .. 140
Neches River, Texas, measurements of 142
stream measurements in basin of..... 141-142
Neosho River, Kansas, measurements of. 115-116
Nepesta, Colo., stream measurements near..... 128-130
New Braunfels, Tex., stream measurements near..... 157
Newell, Colo., stream measurements at 138
Niles, Kans., stream measurements at..... 105-107
Niobrara, Nebr., stream measurements at.. 16-17
Niobrara River, measurements of, at Niobrara, Nebr..... 16-17
measurements of, at Valentine, Nebr.. 18-20
miscellaneous 49
Norfolk, Nebr., stream measurements at... 92
stream measurements near..... 53-55
North Loup River, Nebraska, measurements of..... 92
North Platte, Nebr., stream measurements at..... 62-64, 93
North Platte River, measurements of, at Bridgeport, Nebr..... 64-66
measurements of, at Guernsey, Wyo... 68-70
at Mitchell, Nebr..... 66-68
at North Platte, Nebr..... 62-64
miscellaneous 92
North Platte River, Wyoming, measurements of, miscellaneous..... 94
North Turkey Creek, Colorado, measurements of..... 94
Noyes Ditch, Texas, measurements of..... 156
Ottawa, Kans., stream measurements at... 14-15
Ouachita River, Arkansas, measurements of 140
Oxford, Nebr., stream measurements at. 112-113
Oxford Farmers' Canal, Colorado, measurements of..... 129
Pass Creek, Wyoming, measurements of.... 94
Pecos, Tex., stream measurements near.. 168-172
Pecos River, measurements of, near Moorhead, Tex 166-168
measurements of, near Pecos, Tex... 168-172
Piney Creek, Wyoming, measurements of.. 21
Pittsburg, Tex., stream measurements near. 140
Platte River, measurements of, at Kearney, Nebr..... 92

Page.
Platte River, measurements of, near Columbus, Nebr..... 57-59
measurements of, near Lexington, Nebr. 59-61
stream measurements in basin of 50-94
Prairie Lea, Tex., stream measurements at. 157
Presidio, Tex., stream measurements above..... 177-179
Presidio, Tex., stream measurements below..... 175-177
Pueblo, Colo., stream measurements at .. 130-133
Radersburg, Mont., stream measurements at 50
Red River, Arkansas, measurements of 140
stream measurements in basin of..... 139-140
Redbluff, Mont., stream measurements near 46-47
Reis Springs, Wyo., stream measurements at 94
Republican River, measurements of, at Junction, Kans..... 100-102
measurements of, near Superior, Nebr. 102-105
miscellaneous 112-113
Richmond, Tex., stream measurements at. 147
Rio Grande, N. Mex., stream measurements near 186-189
Rio Grande River, measurements of, above Presidio, Tex 177-179
measurements of, at Eagle Pass, Tex. 158-160
at Embudo, N. Mex 189-192
at Langtry, Tex 172-174
below Presidio, Tex 175-177
near Cenicero, Colo 192-194
near Del Norte, Colo 194-196
near Devils River, Texas..... 161-163
near El Paso, Tex..... 181-183
near Port Hancock, Tex..... 179-180
near Rio Grande, N. Mex..... 186-189
near San Marcial, N. Mex..... 183-186
stream measurements in basin of..... 157-196
Riverside, Tex., stream measurements at. 142-143
Rock Creek, Nebraska, measurements of... 113
Rockyford, Colo., stream measurements near..... 126-127
Sabine River, Texas, measurements of..... 141
stream measurements in basin of..... 140-141
St. Paul, Nebr., stream measurements at... 92
St. Vrain Creek, Colorado, measurements of..... 81-84
Salado, Tex., stream measurements at..... 148
Salado River, Texas, measurements of..... 148
Salesville, Mont., stream measurements near..... 40-43
Salida, Colo., stream measurements at... 136-138
Salina, Kans., stream measurements near. 108-110
Saline River, Kansas, measurements of.. 108-110
Salt Creek, Nebraska, measurements of.... 93
San Antonio, Tex., stream measurements at. 157
San Antonio River, Texas, measurements of..... 157
San Felipe Creek, Texas, measurements of. 161
San Gabriel River, Texas, measurements of..... 148
San Marcial, N. Mex., stream measurements near 183-186
San Marcos River, Texas, measurements of..... 157
San Saba, Tex., stream measurements at... 156
San Saba River, Texas, measurements of. 154-156
Sand Creek, Nebraska, measurements of ... 93

Page.
Sappington, Mont., stream measurements at..... 47–49
Saratoga, Wyo., stream measurements at... 94
Segovia, Tex., stream measurements near.. 154
Seminole Mountains, Wyoming, stream measurements near 94
Seward, Nebr., stream measurements at.... 112
Shawmut, Mont., stream measurements at. 31–32
Shelby, Mont., stream measurements near. 32–34
Shoshone River, Wyoming, measurements of..... 21–23
Simmons, Wyo., stream measurements at.. 94
Sioux Falls, S. Dak., stream measurements at..... 49
Smoky Hill River, Kansas, measurements of..... 110–112
Splitrock, Wyo., stream measurements near 72
Spring Creek, Nebraska, measurements of. 93
Solomon River, Kansas, measurements of. 105–107
South Platte, Colo., stream measurements at 89–92
South Platte River, Colorado, measurements of, at Bigspring, Nebr 72–73
measurements of, at Denver, Colo..... 86–88
at Julesburg, Colo 73–75
at Kersey, Colo..... 77–79
at North Platte, Nebr..... 93
at South Platte, Colo 89–92
miscellaneous 94
Stratton, Nebr., stream measurements at... 112
Stubbs Ferry, Mont., stream measurements at..... 37
Sulphur Fork Creek, Texas, measurements of..... 140
Superior, Nebr., stream measurements near 102–105
Sweetwater River, Wyoming, measurements of..... 71

Page.
Syracuse, Kans., stream measurements at. 123–125
Tarryall Creek, Colorado, measurements of. 94
Thermopolis, Wyo., stream measurements near 23–24
Toston, Mont., stream measurements at.... 37
Townsend, Mont., stream measurements at. 36–38
Trinity River, Texas, measurements of .. 142–143
stream measurements in basin of 142–143
Trout Creek, Colorado, measurements of... 138
Two Medicine Creek, Montana, measurements of..... 34–35
Valentine, Nebr., stream measurements at..... 18–20, 49
Verdigris River, Kansas, measurements of 116–118
Waco, Tex., stream measurements at 143–146
Walhalla, Tex., stream measurements near. 157
Walnut River, Kansas, measurements of... 119
Washita River, Oklahoma, measurements of..... 139–140
Watertown, S. Dak., stream measurements near 15–16
Webster, Colo., stream measurements at... 94
West Gallatin River, Montana, measurements of..... 40–43
West Valley Ditch, Texas, measurements of..... 168–172
Westerfield Ford, Tex., stream measurements at..... 157
White River, Nebraska, measurements of, miscellaneous 49
White Tail Creek, Nebraska, measurements of..... 93
Winston, Colo., stream measurements at... 94
Wood River, Nebraska, measurements of .. 93
Wymore, Nebr., stream measurements at .. 112
Yellowstone River, Montana, measurements of..... 24–26

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1902

BY

F. H. NEWELL

PART IV.—INTERIOR BASIN, PACIFIC COAST, AND HUDSON BAY DRAINAGE

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CONTENTS.

	Page.
Letter of transmittal	9
Introduction	11
Acknowledgments	14
Colorado River drainage basin	15
Colorado River at Yuma, Ariz	17
Colorado River at Bulls Head, Ariz	20
Verde River near McDowell, Ariz	21
Salt River at McDowell, Ariz	23
Salt River at reservoir site below Tonto Creek, near Livingstone, Ariz	25
Tonto Creek near Livingstone, Ariz	29
Gila River at San Carlos, Ariz	32
Animas River at Durango, Colo	35
Florida River near Durango, Colo	37
Los Pinos River at Ignacio, Colo	39
Dolores River at Dolores, Colo	41
Gunnison River at Whitewater, Colo	42
Gunnison River at Iola, Colo	44
Grand River near Palisades, Colo	46
Grand River at Glenwood Springs, Colo	48
White River at Meeker, Colo	50
Uinta River at Ouray School, near Leland, Utah	52
Duchesne River at Price Road bridge, Utah	55
Lake Creek at wagon bridge (near mouth), Utah	58
Uinta River at Fort Duchesne, Utah	61
Uinta River near Whiterocks, Utah	65
Whiterocks River near Whiterocks, Utah	68
Ashley Creek near Vernal, Utah	71
Yampa River at Craig, Colo	74
Green River at Greenriver, Wyo	75
Miscellaneous measurements in the Colorado River drainage basin	77
Interior Basin	78
Bear River near Collinston, Utah	80
Bear River at Battlecreek, near Preston, Idaho	82
Blacksmith Fork at Hyrum, Utah	84
Logan River near Logan, Utah	86
Weber River near Uinta, Utah	87
Provo River near Provo, Utah	88
Sevier River at Gunnison, Utah	88
San Pitch River near Gunnison, Utah	94
Humboldt River near Oreana, Nev	96
Humboldt River near Golconda, Nev	98
Humboldt River at Palisade, Nev	100
Pine Creek at Palisade, Nev	101

Interior Basin—Continued. Page.
Humboldt River (South Fork) at Mason's ranch, near Elko, Nev 101
Humbolt River near Elko, Nev 103
Humboldt River (North Fork) near Halleck, Nev 105
Marys River at Bradley's home ranch, near Deeth, Nev 106
Walker River near Wabuska, Nev 106
Walker River (East Fork) at Ross ranch, near Yerington, Nev 107
Walker River (West Fork) at upper end of Antelope Valley, near Coleville, Cal 108
Carson River near Empire, Nev 109
Carson River (East Fork) at Rodenbah's ranch, near Gardnerville, Nev 111
Carson River (West Fork) at Woodfords, Cal 113
Truckee River at Tahoe, Cal 115
Truckee River at Vista, Nev 117
Truckee River near Mystic, at Nevada-California State line 119
Independence Creek below Independence Lake, near Overton, Cal 121
Prosser Creek below Prosser Creek Ice Company's dam, near Boca, Cal 122
Donner Creek near Donner Ice Company's dam, near Truckee, Cal 123
Susan River near Susansville, Cal 123
Miscellaneous measurements in the Interior Basin 124
San Francisco Bay drainage basin 127
Cache Creek at Lower Lake, Cal 130
Feather River at Oroville, Cal 133
Stony Creek at Julian's ranch, near Fruto, Cal 135
Sacramento River at Jellys Ferry and at Iron Canyon, near Red Bluff, Cal 137
Tuolumne River and Turlock Canal at Lagrange, Cal 142
Merced River above Merced Falls, Cal 147
King River at Kingsburg, Cal 149
King River at Red Mountain, near Sanger, Cal 150
Tule River near Portersville, Cal 151
Kern River near Bakersfield, Cal 154
San Joaquin River at Herndon, Cal 155
Miscellaneous measurements in the San Francisco Bay drainage basin 156
Southern California drainage 163
Arroyo Seco at Pettitt's ranch, near Soledad, Monterey County, Cal 163
San Lorenzo Creek near King City, Cal 166
San Gabriel River and Canals at Azusa, Cal 167
Santa Ana River below Warmsprings, Cal 171
Mohave River at Victorville, Cal 175
Miscellaneous measurements in Southern California drainage 177
Columbia River drainage basin 181
Umatilla River at Gibbon, Oreg 183
Yakima River at Kiona, Wash 186
Yakima River at Union Gap, Wash 188
Naches River near North Yakima, Wash 191
Tieton River near North Yakima, Wash 194
Spokane River at Spokane, Wash 196
Missoula River at Missoula, Mont 199
Bitterroot River near Grantsdale, Mont 201
Palouse River near Hooper, Wash 203
Weiser River near Weiser, Idaho 205
Boise River near Boise, Idaho 207
Seepage measurements in Boise Valley, Idaho 210

Columbia River drainage basin—Continued. Page.
Bruneau River near Grandview, Idaho 212
Snake River at Montgomery Ferry, near Minidoka, Idaho 213
Snake River (North Fork) near Ora, Idaho 215
Fall River near Marysville, Idaho 215
Miscellaneous measurements in the Columbia River drainage basin 216
Puget Sound drainage basin 216
White River at Buckley, Wash 217
Cedar River near Maple Valley, Wash 218
Cedar River at Cedar Lake, near Northbend, Wash 220
Snoqualmie River above Snoqualmie Falls, near Snoqualmie, Wash 220
Skykomish River (South Fork) near Index, Wash 222
Stilaguamish River near Robe, Wash 223
Hudson Bay drainage basin 224
St. Mary River at international line near Cardston, Alberta 225
St. Mary River at Main, Mont 226
Swiftcurrent Creek at Henkel's ranch near St. Mary, Mont 229
St. Mary River at dam site near St. Mary, Mont 231
Red River at Emerson, Manitoba 233
Red Lake River at Crookston, Minn 234
Red River at Grand Forks, N. Dak 235
Sheyenne River at Haggart, N. Dak 236
Red River at Fargo, N. Dak 237
Devils Lake at Devils Lake, N. Dak 238
Index 241

ILLUSTRATIONS.

		Page.
FIG. 1.	Location of river stations and principal irrigation projects in western half of United States, 1902–3	12
2.	Location of river stations in eastern half of United States, 1902–3	13

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., June 29, 1903.

SIR: I have the honor to transmit herewith Water-Supply Paper No. 85, which is Part IV of and completes the report of progress of stream measurements for the year 1902. This paper contains the data which has been received during 1902 from that portion of the territory west of the Mississippi River which does not drain into either the Mississippi River or the western Gulf of Mexico.

This paper contains for the various gaging stations the original data as collected and the results obtained from the discussion of this data, also such other information as is of interest in hydrographic studies.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1902.

PART IV.

By F. H. NEWELL.

INTRODUCTION.

This paper contains data collected during 1902 from that portion of the territory west of Mississippi River which does not drain into either Mississippi River or the western Gulf of Mexico. It completes the Report of the Progress of Stream Measurements for the Year 1902, which report is made up of Water-Supply Papers Nos. 82–85, inclusive.

Water-Supply Papers Nos. 82 and 83 contain the data collected in the territory east of Mississippi River, and papers Nos. 84 and 85 that collected west of Mississippi River. The material in each of these papers consists of both the original data as collected at the various river stations and the results obtained from the discussion of these data; also brief descriptions and facts regarding such other subjects as are allied to hydrographic studies.

For convenience in arrangement the data in this paper have been grouped into the following drainage areas and arranged in the order given: Colorado River drainage, Interior Basin, San Francisco Bay drainage, Southern California drainage, Columbia River drainage, Puget Sound drainage, and Hudson Bay drainage.

On figs. 1 and 2 the dots show the locations of the stations at which the United States Geological Survey is collecting hydrographic data. The section west of the shaded line comprises those States which are covered by the national irrigation act of June 17, 1902 (32 Stat. L., 388–390), and the cross-lined areas show the location of the irrigation projects which are now under investigation.

In collecting hydrographic data the Geological Survey has received the hearty cooperation of various individuals, corporations, and States, as mentioned hereafter. This cooperation has made possible the pub-

lication of many valuable records, which could not otherwise have been obtained.

A brief historical sketch of the stream measurements made by the United States Geological Survey is published on pages 11–15 of Water-Supply Paper No. 75.

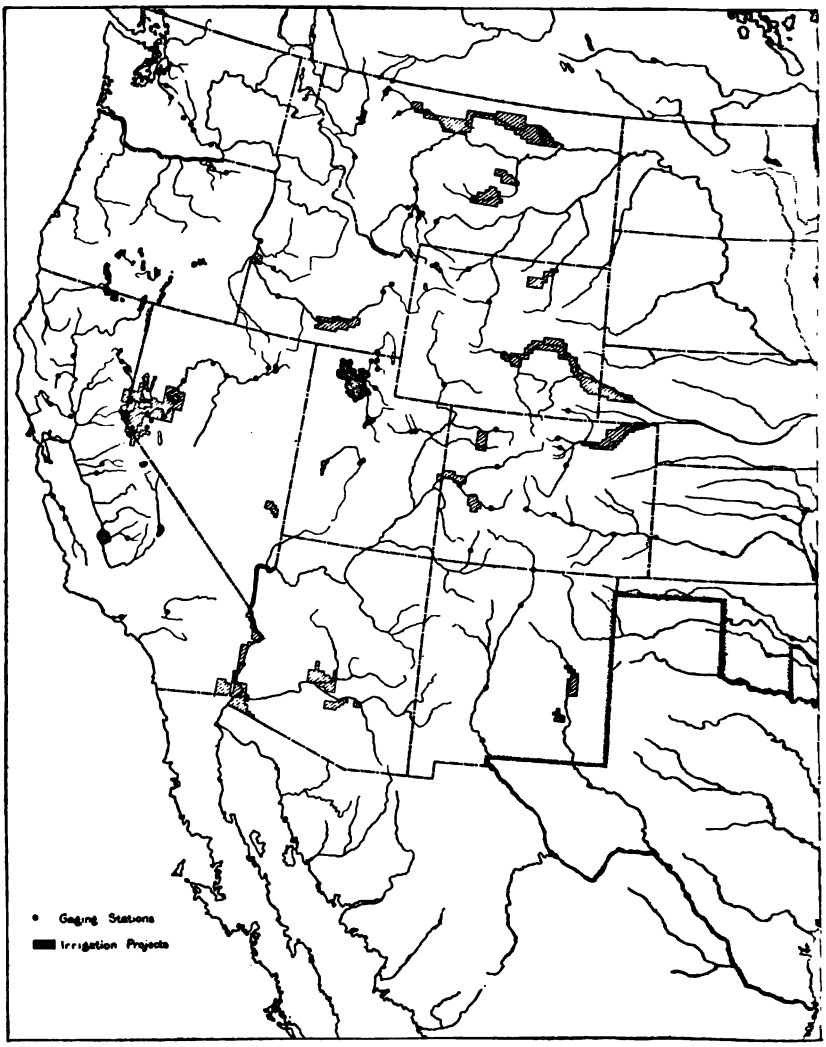

FIG. 1.—Location of river stations and principal irrigation projects in western half of United States, 1902–3

The results of the stream measurements made during the past years by the United States Geological Survey can be found in the following publications, which may be consulted at the public libraries in most of our cities:

1893. Bulletin No. 131.
1894. Bulletin No. 131.

1895. Bulletin No. 140.
1896. Water Supply Paper No. 11, Part IV of the Eighteenth Annual Report.
1897. Water Supply Papers Nos. 15 and 16, Part IV of the Nineteenth Annual Report.
1898. Water Supply Papers Nos. 27 and 28, Part IV of the Twentieth Annual Report.

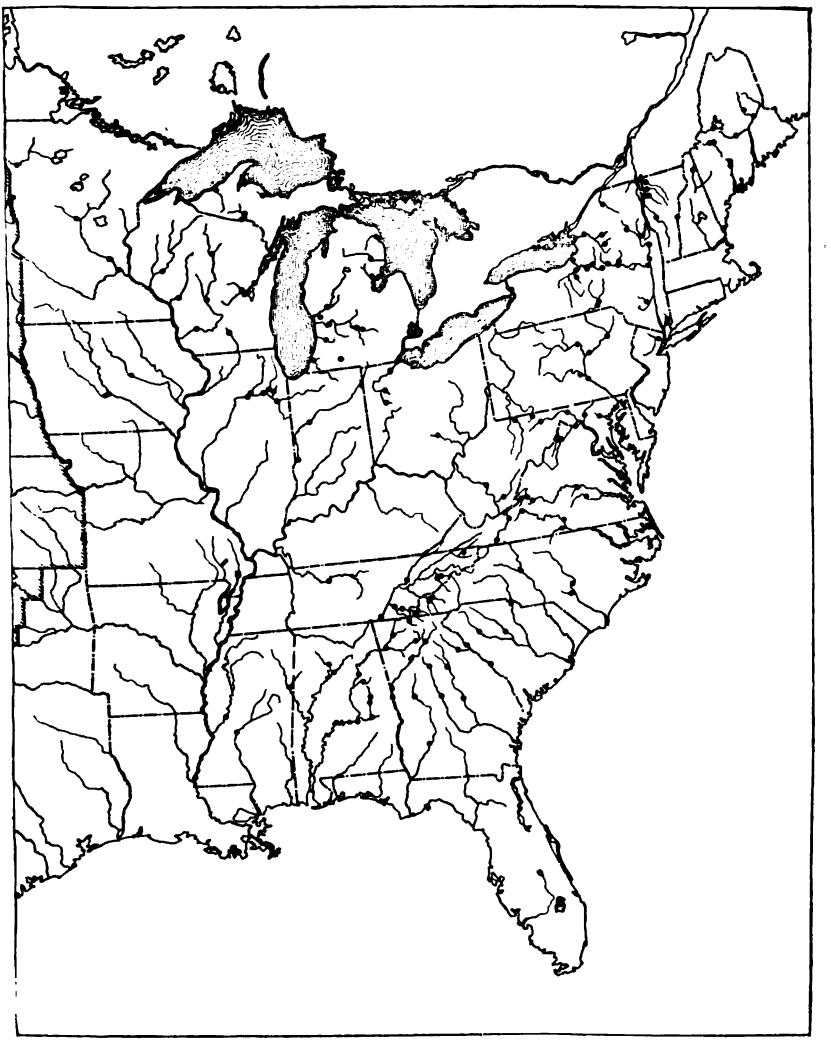

FIG. 2.—Location of river stations in eastern half of United States, 1902-3.

1899. Water Supply Papers Nos. 35 to 39, inclusive, Part IV of the Twenty-first Annual Report.
1900. Water Supply Papers Nos. 47 to 52, inclusive, Part IV of the Twenty-second Annual Report.
1901. Water Supply Papers Nos. 65, 66, and 75.
1902. Water Supply Papers Nos. 82 to 85, inclusive.

ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers and engineers. Acknowledgment is due to each of these persons, and thanks are extended to other persons and corporations who have assisted local hydrographers, or who have cooperated in any way, either by furnishing records or by assisting in transportation.

The following list, arranged alphabetically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Arizona.—The data on Colorado River were collected by J. B. Lippincott and his assistant. That upon the Salt and Gila rivers and Tonto Creek by Stephen Janus and Osburn Richins.

California.—Resident hydrographers, J. B. Lippincott, assisted by Samuel G. Bennett, and L. H. Taylor, assisted by E. C. Murphy and D. W. Hays. Acknowledgments are also due to the following individuals and corporations for assistance rendered and data furnished: To H. F. Parkinson, water overseer for the irrigators in the vicinity of Azusa, Cal., for voluntary observations on San Gabriel River and canals; the Kern County Land Company, through its chief engineer, Walter James, and engineer in charge of water measurements, A. K. Warren, for the record of Kern River; the Southern Pacific Company, through its chief engineer William Hood, for river stage records of San Joaquin River at Herndon, Cal., and the King River at Kingsburg, also for transportation furnished the resident hydrographers and assistants; to the officials of the Santa Fe Route and Lake Tahoe Railway and Transportation Company for transportation of the resident hydrographers and assistants.

Colorado.—Resident hydrographer, A. L. Fellows, assisted by M. C. Hinderlider. Acknowledgments for assistance rendered and data furnished are due to Hon. A. J. McCune, State engineer of irrigation; A. F. Reeves, superintendent of irrigation, and to various water commissioners who are located in this division and who have given their assistance from time to time. Transportation has been furnished by the Denver and Rio Grande; Atchison, Topeka and Santa Fe; Colorado and Southern, and Rio Grande Southern railroads. Special assistance was also rendered by William H. Richardson at Glenwood Springs.

Idaho.—Resident hydrographer, N. S. Dils. Acknowledgments are due to the Oregon Short Line Railway Company for transportation furnished N. S. Dils.

Minnesota.—The data from this State were collected by the late C. M. Hall.

Montana.—Resident hydrographer, J. S. Baker, assisted by H. B. Waters.

Nevada.—Resident hydrographer, L. H. Taylor, assisted by E. C. Murphy and D. W. Hays. Acknowledgments are also due to the Southern Pacific Railroad Company and Lake Tahoe Railway and Transportation Company for transportation furnished.

North Dakota.—The data from this State were collected by the late C. M. Hall.

Oregon.—Resident hydrographer, Sydney Arnold.

Utah.—Resident hydrographers, Howard S. Reed and George L. Swendsen, assisted by W. D. Beers, Caleb Tanner, and W. G. Swendsen. Acknowledgments for assistance rendered and data furnished are due to the Utah Light and Power Company, Ogden, Utah; the Hercules Power Company, Logan, Utah, and the Bear River Canal Company, Corinne, Utah.

Washington.—Resident hydrographers, T. A. Noble, assisted by H. W. Quinan and Sydney Arnold. Acknowledgments are also due to the following individuals

or assistance rendered and data furnished: To Reginald H. Thomson, city engineer of Seattle, Wash.; to Louis G. Heybrock, who has been voluntary observer at the station of the south fork of Skykomish River, and to A. A. Batcheller, who has been voluntary observer at the station on Cedar River at Cedar Lake, and to James J. Hill, who has furnished transportation to the resident hydrographer in the State of Washington over the Great Northern Railway. Transportation has been furnished to Sydney Arnold by Thomas Cooper, general manager of the Northern Pacific Railway, thus greatly facilitating the extension of the field work.

Wyoming.—Resident hydrographer, A. J. Parshall. Acknowledgments are also due to H. G. Burt, president of Union Pacific Railroad Company, for transportation furnished over its lines in Wyoming to the resident hydrographer.

COLORADO RIVER DRAINAGE BASIN.

Topographically considered, this is the largest hydrographic basin lying wholly within the arid region, having a total area above the town of Yuma, Ariz., of over 225,000 square miles.

This basin is situated in Wyoming, Utah, Colorado, Arizona, New Mexico, Nevada, and California, but the principal water supply comes from the melting snows of the high mountains of Wyoming, Utah, and Colorado. The minimum flow is less than 3,000 cubic feet per second. The maximum reaches more than 50,000 cubic feet per second.

This stream has been called the Nile of America. Like the Nile, the Colorado is subject to an annual summer rise, which comes at a time when it is most needed for irrigation. Its waters carry a large amount of sediment, reaching as high as 2,000 parts of sediment to 100,000 parts of water. The minimum amount is carried during the winter months and probably is never less than 60 parts of sediment to 100,000 parts of water.

Prof. R. H. Forbes, in Bulletin No. 44, University of Arizona Agricultural Experiment Station, says:

> On the basis of the profile constructed from available data for the volume of flow of the Colorado, and of the year's silt determinations made in this laboratory, it is estimated conservatively that the river during 1900 brought down about 31,000,000 tons of sedimentary material, which, condensed to the form of solid rock, is enough to cover 26.4 square miles 1 foot deep, or to make 53 square miles of dry, alluvial soil 1 foot deep, or to make about 164 square miles of recently settled, submerged mud 1 foot deep, reckoning the whole amount of mud for the year to average 6.2 times the bulk of the solid sediment.

Comparatively a small amount of land is irrigated by the waters of Colorado River, owing to the fact that the main stream and both of its tributaries are situated so far below the level of the irrigable lands as to render their diversion extremely difficult or impracticable.

There are two pumping plants that lift water for irrigation at Yuma and several at other points on the river above Yuma. The Imperial canal diverts water at a point on the right bank of the river 6 miles below Yuma. It is the intention of the owners of this canal to reclaim a large tract of fertile land situated in Mexico and in California.

The system is still in process of construction. On December 4, 1902, this canal was carrying 494 second-feet of water.

During December, 1901, and January, 1902, a reconnaissance of Colorado River and valley was made from the Needles and Yuma by J. B. Lippincott and others. In October, 1902, a reconnaissance was made by Mr. Lippincott, beginning at a point called Greggs Ferry, Mohave County, Ariz., and extending to the Needles, Cal.

Numerous dam and reservoir sites and diversion points for canals were discovered, together with large tracts of fertile land capable of being irrigated. In November, 1902, extensive topographical, soil, and hydrographic surveys were begun in Colorado River Valley by the Reclamation Service of the Geological Survey.

Colorado River is formed by Grand and Green rivers, in the southeastern part of Utah. Of its tributaries, Gila River rises in the western part of New Mexico and flows west into the Colorado, at Yuma, Ariz., draining the southern half of Arizona. Salt River, its principal tributary, joins it about 15 miles west of Phœnix, Ariz. Rio Verde and Tonto Creek are tributaries of Salt River from the north. The San Juan River, with its tributaries, drains southwestern Colorado, northwestern New Mexico, and northeastern Arizona. It takes a generally westward course into the Colorado, north of the Utah-Arizona boundary. Animas, Los Pinos, and Florida rivers are tributaries in southwestern Colorado. Grand River has its source on the Continental Divide, in the northern part of Colorado, and flows southwest to its junction with Green River. Gunnison River, its principal tributary, joins it from the south, a short distance south of Grand Junction, Colo. Dolores River rises in southwestern Colorado and flows northwest into the Grand, in eastern Utah. Green River rises in the Wind River Range of mountains in the western central part of Wyoming, its main source being in the lofty peaks of the Continental Divide. The source of its tributaries is also among the higher snow-covered ranges, maintaining the volume of this stream late into the summer. The principal branches of White River rise in the White River Plateau, a well-forested tract in the White River Forest Reserve. A number of lakes, among which are Oyster, Marvin, Traverse, and Deep lakes, furnish important reservoir sites, if such are ever needed. Duchesne River, with its tributaries, the Uinta, Lake Creek, and Whiterocks River, flows into the Green, near the mouth of White River, and near Ouray, Utah. The Ashley is a small tributary of the Green, in northeastern Utah. Yampa River rises in the eastern part of Routt County, Colo., and flows in a general westerly direction through the entire county and empties into Green River, near the western boundary. The stream is somewhat peculiar in its character, the upper branches having considerable fall, and the water, therefore, flowing rapidly over shoals of gravel and rock, is thus easily taken out for utiliza-

tion. The following is a list of the stations in the Colorado River drainage basin:

Colorado River at Yuma, Ariz.
Colorado River at Bulls Head, Ariz.
Verde River near McDowell, Ariz.
Salt River at McDowell, Ariz.
Salt River at reservoir site, below Tonto Creek, near Livingstone, Ariz.
Tonto Creek near Livingstone, Ariz.
Gila River at San Carlos, Ariz.
Animas River at Durango, Colo.
Florida River near Durango, Colo.
Los Pinos River, at Ignacio, Colo.
Dolores River at Dolores, Colo.
Gunnison River at Whitewater, Colo.
Gunnison River at Iola, Colo.
Grand River at Palisades, Colo.
Grand River at Glenwood Springs, Colo.
White River at Meeker, Colo.
Uinta River at Ouray School, near Leland, Utah.
Duchesne River at Price Road Bridge, Utah.
Lake Creek at Wagon Bridge (near mouth), Utah.
Uinta River at Fort Duchesne, Utah.
Uinta River near Whiterocks, Utah.
Whiterocks River near Whiterocks, Utah.
Ashley Creek near Vernal, Utah.
Yampa River at Craig, Colo.
Green River at Greenriver, Wyo.

COLORADO RIVER AT YUMA, ARIZ.

Records of river height have been maintained by the Southern Pacific Railroad Company at their bridge since April 1, 1878. The gage at this point, reading from 10 to 22 feet, is nailed to the lower side of the first pier from the south bank of the river; the portion reading from 22 feet to 40 feet is nailed to an 8-inch by 8-inch post on the north side east of the bridge. The gage height plus 100 feet is the Southern Pacific elevation above sea level. The channel of the river shifts very rapidly, the bed silting and scouring with every change of river height, so that the relation of gage height to discharge is not constant.

Meter measurements have been made at this point by the Survey at various times since April, 1895, but on account of the shifting character of the channel no rating table has been constructed until this year. This rating table, which is applicable from January 1 to October 10, 1902, is approximate only. The discharge from October 10 to December 31 was estimated from numerous meter measurements.

Discharge measurements of Colorado River at Yuma, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
January 9	J. B. Lippincott	17.20	3,637
February 20	S. G. Bennett	17.15	3,229
May 30	do	23.00	38,400
July 7	W. W. Follett	21.06	18,350
July 9	S. G. Bennett	20.52	14,799
October 11	do	18.50	6,030
October 14	R. P. H. Laney	17.90	4,798
October 17	do	17.50	3,559
October 21	do	17.60	4,203
October 24	do	17.50	3,547
November 12	S. G. Bennett	17.40	3,614
November 13	do	17.50	3,865
November 15	W. D. Smith	18.55	5,276
November 18	do	18.05	4,213
November 20	do	18.00	4,368
November 22	do	18.10	4,600
November 24	do	18.45	5,500
November 26	do	18.40	4,979
November 28	do	18.50	5,544
December 1	do	20.00	12,596
December 3	do	19.25	7,862
December 5	do	18.85	6,347
December 8	do	18.30	4,825
December 10	do	18.20	5,081
December 12	do	18.00	4,669
December 15	do	17.65	3,818
December 16	do	17.50	3,589
December 18	do	18.30	5,361
December 19	do	18.05	4,607
December 20	do	18.05	5,237
December 22	do	17.70	4,698
December 24	do	18.00	4,862
December 26	do	18.10	5,356
December 27	do	18.30	5,497
December 29	do	18.00	4,588
December 31	do	17.70	4,176

Daily gage height, in feet, of Colorado River at Yuma, Ariz.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	17.10	18.00	17.90	18.20	20.00	22.30	22.00	18.40	17.50	18.90	17.40	20.00
2	17.00	18.00	17.90	18.00	20.70	22.20	21.70	18.30	17.30	18.50	17.30	19.50
3	17.00	18.00	18.00	17.90	20.80	22.20	21.50	18.30	17.00	18.40	17.30	19.30
4	17.00	17.90	17.90	17.90	20.50	22.70	21.30	18.30	18.00	18.60	17.30	19.00
5	17.00	17.90	17.90	17.90	20.30	23.10	21.10	18.10	18.80	18.30	17.30	18.90
6	17.00	17.80	17.90	18.00	20.30	23.10	20.80	18.00	18.80	18.10	17.30	18.60
7	17.00	17.70	18.10	18.00	20.40	23.50	20.70	17.90	18.00	18.00	17.20	18.40
8	17.20	17.70	18.20	18.20	20.50	23.70	20.60	17.80	17.60	18.10	17.20	18.30
9	17.20	17.60	18.10	18.20	20.30	24.00	20.40	17.80	17.50	18.10	17.20	18.30
10	17.30	17.50	18.10	18.20	20.50	24.20	20.30	17.80	17.30	18.10	17.30	18.20
11	17.30	17.50	18.10	18.20	22.00	24.30	20.30	17.70	17.30	18.50	17.30	18.10
12	17.30	17.60	18.10	18.20	22.30	24.20	20.60	17.70	17.30	18.30	17.40	18.00
13	17.30	17.10	18.20	18.20	22.30	24.30	20.50	17.60	17.30	18.00	17.50	18.10
14	17.30	17.10	18.20	18.20	22.80	24.00	20.20	17.60	17.30	17.80	18.00	17.70
15	17.30	17.20	18.30	18.20	22.90	23.80	20.10	17.50	17.30	17.80	18.50	17.60
16	17.30	17.30	18.40	18.20	23.20	23.90	20.00	17.40	17.20	17.60	18.00	17.50
17	17.40	17.30	18.40	18.10	23.50	23.70	20.30	17.30	17.70	17.60	17.80	17.70
18	17.60	17.30	18.30	18.00	23.70	23.80	19.80	17.30	17.50	17.40	18.10	18.30
19	17.70	17.30	18.30	18.00	24.10	23.70	19.80	17.10	17.30	17.60	18.10	18.10
20	17.70	17.20	18.30	18.00	24.30	23.60	19.70	17.00	17.30	17.60	18.10	18.00
21	17.70	17.10	18.30	18.00	24.30	23.50	19.50	17.80	17.00	17.40	18.00	17.80
22	17.70	17.30	18.30	18.30	24.40	23.50	19.40	18.50	16.80	17.40	18.10	17.80
23	17.70	17.70	18.30	19.30	24.40	23.20	19.30	18.30	16.80	17.30	18.10	17.80
24	17.70	18.00	18.30	19.80	24.40	23.10	19.40	17.90	16.90	17.30	18.40	18.00
25	17.80	18.10	18.30	19.80	24.40	23.00	19.10	17.80	17.10	17.30	18.50	18.20
26	17.90	18.10	18.20	19.80	24.50	22.70	19.30	18.00	16.80	17.30	18.40	18.10
27	17.90	18.10	18.30	19.90	24.30	22.60	19.00	17.90	16.70	17.30	18.50	18.30
28	17.90	18.00	18.30	20.00	24.00	22.50	18.80	17.70	16.60	17.30	18.50	18.20
29	17.80	.....	18.30	19.80	23.50	22.30	18.50	17.30	17.50	17.20	18.50	18.00
30	18.00	.....	18.30	19.80	23.00	22.20	18.40	17.20	19.40	17.20	18.30	17.80
31	18.00	.....	18.30	.....	22.70	.....	18.30	17.20	.....	17.30	.....	17.70

Rating table for Colorado River at Yuma, Ariz., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
16.5	3,030	18.2	4,920	20.4	13,800	22.6	33,400
16.6	3,050	18.4	5,340	20.6	15,200	22.8	35,800
16.7	3,080	18.6	5,790	20.8	16,600	23.0	38,200
16.8	3,120	18.8	6,310	21.0	18,200	23.2	40,800
16.9	3,170	19.0	6,910	21.2	19,800	23.4	43,400
17.0	3,230	19.2	7,590	21.4	21,500	23.6	46,100
17.2	3,380	19.4	8,360	21.6	23,300	23.8	48,900
17.4	3,580	19.6	9,300	21.8	25,100	24.0	51,700
17.6	3,850	19.8	10,300	22.0	27,000	24.2	54,700
17.8	4,160	20.0	11,400	22.2	29,000	24.4	57,700
18.0	4,520	20.2	12,600	22.4	31,200	.....	.....

Estimated monthly discharge of Colorado River at Yuma, Ariz.

[Drainage area, 225,049 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	4,520	3,230	3,727	229,164	0.017	0.020
February	4,720	3,300	3,955	219,650	.018	.019
March	5,340	4,340	4,903	301,474	.022	.025
April	11,400	4,340	6,179	367,676	.027	.030
May	59,200	11,400	35,961	2,211,156	.160	.184
June	56,200	29,000	42,520	2,530,115	.189	.211
July	27,000	5,130	12,527	770,255	.056	.065
August	5,560	3,230	4,183	257,203	.019	.022
September	8,360	3,050	3,819	227,246	.017	.019
October	6,600	3,140	4,299	264,335	.019	.022
November	5,540	3,140	4,187	249,144	.019	.021
December	12,600	3,590	5,412	332,771	.024	.028
The year	59,200	3,050	10,973	7,960,189	.049	.66[illegible]

COLORADO RIVER AT BULLS HEAD, ARIZ.

A gaging station was established at a point of rocks on Colorado River, known as the Bulls Head, by E. T. Perkins, engineer. The station is situated at the Bulls Head, 35 miles north of Needles, Cal., and is accessible only by wagon road up the Arizona side of the river. A cable was stretched across the river at this point on December 1, 1902. T. M. Whedbee, hydrographic aid, was assigned as observer. He resided at the engineering camp, which had headquarters at this locality.

The river was measured with a Price electric-current meter three times a week, and rod readings were taken daily. Mr. Whedbee is believed to be a reliable and accurate observer. The equipment consisted of a five-eighths-inch cable and a gaging car and tag wire. The station was maintained as long as the engineering camp remained at the Bulls Head, and then the material was removed and stored at the Needles, with the exception of the gage rod.

The gage is an inclined wooden rod divided into tenths of a foot. It is well painted and is fastened to the left rock bank of the river. A bronze bench-mark tablet is set on the Arizona side in the rock about 20 feet above low-water mark and about 50 feet downstream from the gage rod. The elevation of the bench mark is 530.523 feet

above sea level and the zero of the rod equals an elevation of 499.902 feet. The initial point for soundings is the left bank. The river channel is straight for about 1,000 feet above and 500 feet below the cable station and the current is rather swift. The banks are high and rocky, but the channel of the river is shifting silt. A determination was made of the value of "*n*" at this gaging station. It was found that "*n*" equaled 0.010.

Discharge measurements of Colorado River at Bulls Head.

Date.	Hydrographer	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
December 5	J. T. Whistler	3.00	5,786
December 10	L. M. Barnes	2.65	4,051
December 13	do	2.45	3,222
December 17	do	2.95	4,138
December 20	do	3.50	4,792
December 24	do	3.23	4,939
December 29	do	2.45	3,366
December 31	do	2.20	2,913

VERDE RIVER NEAR M'DOWELL, ARIZ.

A number of large irrigation enterprises have been planned, designed to divert water from the lower stretch of this river to irrigate lands north of Phœnix, but none has been constructed. The results of measurements of this river combined with those of Salt River show the amount of water available for the irrigable lands of Phœnix Valley. The dam of the Arizona Canal Company is located on Salt River immediately below the mouth of the Verde. The gaging station on the Verde is located three-fourths of a mile above its mouth and 30 miles northeast of Phœnix. It was established April 20, 1897. The station is equipped with a cable, car, and tagged wire. The gage consists of a 2 by 4 inch inclined rod fastened to posts driven into the east bank of the river about 400 feet below the gaging cable. The bench mark is on a cat's-claw tree (*Acacia*) about 100 feet southeast of the old gage, on a cottonwood tree, which is 60 feet below the cable. The elevation of the bench mark is 27.02 feet above gage datum. The channel of the river is similar to that of Salt River—sandy and liable to change during a slight rise, and a large number of measurements are necessary in order to accurately determine the discharge.

Discharge measurements of Verde River near McDowell, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 4	J. Fred Appleby	5.33	234
January 11	do	5.36	222
January 19	do	5.29	197
January 25	do	5.35	263
January 27	do	5.41	239
February 1	do	5.45	241
February 8	do	5.35	253
February 15	do	5.32	241
February 22	do	5.31	239
March 1	do	5.40	245
March 8	W. Richins	5.40	251
March 15	do	5.41	233
March 22	do	5.35	208
March 26	do	5.48	281
March 29	do	5.50	273
April 1	do	5.95	436
April 5	do	5.52	252
April 8	do	5.42	241
April 10	do	5.50	256
April 15	do	5.20	150
April 19	do	5.10	116
July 14	Frank P. Trott	4.47	37
July 19	do	4.58	49
July 26	do	5.00	148

Daily gage height, in feet, of Verde River near McDowell, Ariz.

Day.	Jan.	Feb.	Mar.	Apr.	July.
1902.					
1	5.33	5.44	5.40	5.93	.....
2	5.34	5.43	5.42	5.93	.....
3	5.34	5.43	5.42	5.68	.....
4	5.33	5.40	5.43	5.63	.....
5	5.33	5.39	5.44	5.51	.....
6	5.33	5.39	5.42	.....	.....
7	5.39	5.40	5.40	5.42	.....
8	5.35	5.34	5.40	5.44	.....
9	5.34	5.36	5.37	5.55	.....
10	5.32	5.38	5.40	5.49	.....
11	5.36	5.36	5.40	5.42	.....
12	5.35	5.35	5.47	5.39	.....
13	5.36	5.38	5.43	.....	.....
14	5.35	5.38	5.42	5.27	.....
15	5.33	5.32	5.41	5.20	.....
16	5.29	5.32	5.41	5.17	.....
17	5.29	5.31	5.41	5.15	.....
18	5.29	5.33	5.41	5.11	.....
19	5.29	5.36	5.41	5.10	.....
20	5.31	5.34	5.40	.....	.....
21	5.32	5.32	8.39	.....	.....
22	5.33	5.31	5.35	.....	.....
23	5.33	5.33	.....	.....	4.90
24	5.33	5.32	5.35	.....	4.85
25	5.36	5.37	5.40	.....	7.44
26	5.45	5.42	5.52	.....	5.00
27	5.41	5.39	5.47	.....	.....
28	5.38	5.36	5.49	.....	.....
29	5.39	.....	5.49	.....	.....
30	5.45	.....	.....	.....	.....
31	5.43	.....	5.42	.....	.....

SALT RIVER AT M'DOWELL, ARIZ.

Irrigation is practiced to a small extent on Salt River in what is known as Tonto Valley, but shortly after Tonto Creek joins it the river enters a canyon and continues in it until a short distance above the mouth of Verde River. At this point the river reappears from its canyon, and its course is thence across the Plains district until it enters Gila River at the northwest corner of Gila River Indian Reservation. From the mouth of Verde River down to Gila River a number of large canals divert the water of Salt River and serve the extensively irrigated lands in the vicinity of Phœnix on the north side and Mesa on the south side of the river. During ordinary seasons all of the water of Salt River is diverted, and at the present time there is a shortage in the summer months. The gaging station, established April 20, 1897, is located 4,000 feet above the mouth of the Verde and 30 miles northeast of Phœnix. The gage consists of a 2 by 6 inch scantling bolted to rocks on the south side of the river about 300 feet above the cable. The bench mark is a nail in a palo verde tree

about 75 feet west of the north cable anchorage and is 17.33 feet above gage zero The bed of the river is sandy and shifting, and it is necessary to make a large number of measurements in order to obtain an accurate estimate of the discharge.

The station was temporarily discontinued during 1900, but measurements were resumed in 1901.

Discharge measurements of Salt River at McDowell, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 4	J. Fred Appleby	0.82	154
January 11	do	.79	157
January 19	do	.82	153
January 25	do	.85	170
January 27	do	1.03	214
February 1	do	.99	179
February 8	do	.92	185
February 15	do	.90	189
February 22	do	.89	191
March 1	do	.97	194
March 8	W. Richins	.91	193
March 15	do	.87	194
March 22	do	.85	206
March 26	do	1.02	238
March 29	do	.96	229
April 1	do	.92	208
April 5	do	1.00	231
April 8	do	1.12	282
April 10	do	1.35	357
April 15	do	1.26	333
April 19	do	1.12	272
July 14	F. P. Trott	.13	56
July 19	do	.61	126
December 24	W. Richins	1.30	417

Daily gage height, in feet, of Salt River at McDowell, Ariz., for 1902.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1	0.79	0.99	0.96	0.91	17	0.82	0.91	0.88	1.19
2	.79	.97	.96	.91	13	.82	.90	.88	1.14
3	.79	.94	.94	.91	19	.81	.90	.85	1.12
4	.83	.91	.93	.93	20	.83	.89	.85	.....
5	.82	.90	92	.99	21	.83	.89	.85	.....
6	.81	.92	.92	1.06	22	.83	.89	.85	.....
7	.83	.93	.92	1.07	23	.83	.89	.89	.....
8	.81	.92	.91	1.14	24	.83	.89	.92	.....
9	.80	.92	.89	1.28	25	.85	.90	1.04	.....
10	.81	.91	.91	1.37	26	1.02	.93	1.01	.....
11	.78	.90	.88	1.40	27	1.03	.93	1.00	.....
12	.77	.90	.87	1.40	28	1.02	.96	.99	.....
13	.81	.90	.87	1.35	29	.98	.....	.96	.....
14	.81	.90	.87	1.30	30	1.06	.....	.93	.....
15	.81	.90	.87	1.24	31	1.03	.....	.90	.....
16	.81	.91	.88	1.21					

Estimated monthly discharge of Salt River at McDowell, Ariz.

[Drainage area, 6,260 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	250	137	176	10,816	0.028	0.032
February	231	193	198	11,020	.032	.033
March	250	174	197	12,131	.031	.036
April 1 to 19	.....	.....	287	10,816	.046	.032

SALT RIVER AT RESERVOIR SITE, NEAR LIVINGSTONE, ARIZ.

The station, established February 7, 1901, by H. G. Heisler, is 15 miles west of Livingstone, Ariz. The rod is on the left bank of the river at the upper end of the gorge. Gagings are made from a traveling car suspended from a cable.

Discharge measurements of Salt River at reservoir site near Livingstone, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 4	W. Richins	7.02	174
January 8	do	7.00	174
January 11	do	6.98	164
January 14	do	7.03	188
January 17	do	7.01	174
January 20	do	7.02	176
January 24	do	7.02	172
January 27	do	7.19	235
January 31	do	7.13	215
February 4	Osburn Richins	7.09	192
February 7	do	7.10	200
February 11	do	7.09	187
February 14	do	7.10	192
February 18	do	7.09	190
February 21	do	7.09	192
February 25	do	7.10	185
February 28	do	7.19	215
March 4	do	7.13	193
March 7	do	7.09	181
March 11	do	7.12	200
March 14	do	7.09	181
March 19	do	6.90	174
March 21	do	6.92	173
March 25	do	7.20	214
March 28	do	7.17	193
April 4	do	7.24	244
April 7	do	7.30	267
April 10	do	7.51	361
April 14	do	7.41	304
April 18	do	7.30	259
April 21	do	7.23	222
April 25	do	7.19	199
April 30	do	6.98	158
May 5	do	6.89	147
May 8	do	6.90	147
May 13	do	6.80	118
May 15	do	6.80	125
May 19	do	7.47	324
May 23	do	6.92	166

Discharge measurements of Salt River at reservoir site near Livingstone, Ariz.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
May 27	Osburn Richins	7.29	256
June 2	do	7.09	189
June 6	do	6.89	148
June 10	do	6.71	98
June 14	do	6.64	91
June 26	do	6.48	91
June 29	do	6.45	86
June 30	do	6.58	70
July 6	do	6.41	80
July 12	do	6.35	69
July 18	do	6.84	150
July 23	do	6.65	106
July 31	do	6.40	79
August 4	do	7.04	90
August 8	do	7.59	373
August 9	do	7.85	657
August 11	do	8.96	2,401
August 18	do	7.00	187
August 24	do	7.84	541
September 1	do	6.91	125
September 5	do	8.05	798
September 11	do	7.10	212
September 18	do	7.00	178
September 19	do	8.65	2,045
September 20	do	9.30	3,943
October 6	do	6.81	149
October 13	do	6.80	147
October 27	do	6.80	139
November 7	do	6.81	145
November 13	do	7.55	478
November 20	do	6.92	188
November 23	do	7.23	344
December 2	do	6.90	191
December 13	do	8.10	774
December 14	do	9.00	2,477
December 29	do	7.21	317

Daily gage height, in feet, of Salt River at the reservoir site near Livingstone, Ariz.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.99	7.13	7.19	7.12	6.83	7.10	6.44	6.37	6.91	7.04	6.81	6.9[illegible]
2	6.98	7.12	7.14	7.12	6.48	7.65	6.43	6.35	6.86	7.00	6.81	6.9[illegible]
3	7.01	7.10	7.15	7.19	6.55	6.98	6.42	7.23	6.83	6.91	6.81	6.9[illegible]
4	7.02	7.09	7.13	7.24	6.80	6.92	6.42	6.95	6.80	6.86	6.81	6.9[illegible]
5	7.01	7.10	7.13	7.24	6.89	6.90	6.42	6.43	7.85	6.81	6.81	6.9[illegible]
6	7.01	7.10	7.12	7.29	6.87	6.87	6.41	6.90	7.30	6.81	6.81	6.9[illegible]
7	7.01	7.11	7.10	7.32	6.89	6.82	6.40	7.38	7.25	6.81	6.81	6.9[illegible]
8	7.00	7.11	7.09	7.43	6.90	6.80	6.40	7.85	6.93	6.80	6.81	6.9[illegible]
9	7.00	7.11	7.13	7.51	6.88	6.80	6.38	7.58	6.90	6.80	6.81	6.9[illegible]
10	6.99	7.11	7.11	7.51	6.83	6.73	6.36	7.43	7.10	6.80	6.83	6.92
11	6.98	7.11	7.05	7.50	6.81	6.71	6.36	8.55	7.16	6.80	6.95	6.92
12	7.01	7.11	7.11	7.47	6.81	6.68	6.35	9.68	7.07	6.80	7.37	6.92
13	7.03	7.11	7.11	7.47	6.80	6.66	6.33	7.90	6.99	6.80	7.50	[illegible]
14	7.04	7.11	7.09	7.39	6.80	6.65	6.31	7.30	6.98	6.80	7.12	[illegible]
15	7.01	7.10	7.09	7.38	6.80	6.65	6.31	7.23	7.14	6.78	7.09	[illegible]
16	7.02	7.10	7.11	7.31	6.80	6.64	6.41	7.17	7.08	6.78	7.00	[illegible]
17	7.01	7.10	7.10	7.31	6.80	6.64	6.45	7.05	7.03	6.78	6.99	[illegible]
18	7.01	7.09	6.65	7.29	6.83	6.62	6.78	6.98	7.00	6.79	6.94	[illegible]
19	7.02	7.10	6.85	7.29	7.30	6.60	6.62	6.94	7.75	6.80	6.92	[illegible]
20	7.02	7.10	6.94	7.25	7.00	6.58	6.60	6.90	9.50	6.80	6.92	[illegible]
21	7.03	7.10	6.91	7.23	6.97	6.54	6.58	6.83	9.59	6.80	7.66	[illegible]
22	7.03	7.10	6.99	7.22	6.95	6.52	6.56	6.80	9.46	6.80	7.64	[illegible]
23	7.02	7.10	7.06	7.22	6.93	6.51	6.67	6.77	9.29	6.80	7.26	[illegible]
24	7.02	7.11	7.17	7.21	7.02	6.49	6.97	8.32	9.13	6.80	7.12	[illegible]
25	7.09	7.10	7.20	7.19	7.19	6.49	6.79	7.95	9.00	6.80	7.10	[illegible]
26	7.20	7.13	7.20	7.19	7.25	6.48	6.84	7.56	8.75	6.80	7.02	[illegible]
27	7.19	7.20	7.19	7.19	7.29	6.46	6.76	7.40	8.43	6.80	6.99	[illegible]
28	7.13	7.18	7.15	7.18	7.29	6.45	6.73	7.27	7.75	6.80	6.98	[illegible]
29	7.14	.....	7.12	7.09	7.30	6.45	6.63	7.11	7.35	6.80	6.95	[illegible]
30	7.18	.....	7.12	6.97	7.19	6.44	6.51	7.07	7.15	6.81	6.94	[illegible]
31	7.13	.....	7.11	.....	7.14	.....	6.40	6.97	.....	6.81	.....	[illegible]

Rating table for Salt River at reservoir site near Livingstone, Ariz., for 1902.

Gage height.	Discharge.	Gage height.	Dischage.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.2	33	7.1	204	8.0	765	8.9	2,675
6.3	45	7.2	236	8.1	915	9.0	2,925
6.4	58	7.3	272	8.2	1,090	9.1	3,175
6.5	72	7.4	310	8.3	1,290	9.2	3,425
6.6	88	7.5	350	8.4	1,500	9.3	3,675
6.7	106	7.6	400	8.5	1,715	9.4	3,925
6.8	126	7.7	462	8.6	1,940	9.5	4,175
6.9	150	7.8	540	8.7	2,175	.....	.....
7.0	176	7.9	640	8.8	2,425	.....	.....

Estimated monthly discharge of Salt River at reservoir site near Livingstone, Ariz.

[Drainage area, 5,756 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	236	176	189	11,621	0.033	0.038
February	236	204	207	11,496	.036	.037
March	236	97	201	12,359	.035	.040
April	350	163	268	15,947	.047	.052
May	272	72	167	10,268	.029	.033
June	204	65	106	6,307	.018	.020
July	163	45	78	4,796	.014	.016
August	4,675	52	478	29,391	.083	.096
September	4,425	138	1,057	62,896	.184	.205
October	190	126	131	8,055	.023	.027
November	431	126	189	11,246	.033	.037
December	2,800	150	441	27,116	.077	.089
The year	4,675	45	293	211,498	.051	.690

TONTO CREEK NEAR LIVINGSTONE, ARIZ.

The station, established April 1, 1901, by H. G. Heisler, is 15 miles west of Livingstone, Ariz. It is about half a mile above the mouth. The gage is a vertical rod nailed to a cliff of cemented gravel on the left bank.

Discharge measurements of Tonto Creek near Livingstone, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 4	W. Richins	2.90	3
January 17	do	2.90	3
January 24	do	2.90	3
January 27	do	2.95	3
February 4	O. Richins	2.95	3
February 7	do	2.95	3
February 11	do	2.95	3
February 14	do	2.95	3
February 18	do	2.95	3
February 21	do	2.95	3
February 25	do	2.93	3
February 28	do	2.95	3
March 4	do	2.94	3
March 7	do	2.94	3
March 11	do	2.95	3
March 14	do	2.91	3
March 19	do	2.92	3
March 21	do	2.90	3
March 28	do	2.91	3
April 4	do	2.91	3
April 7	do	2.91	3
April 14	do	2.91	3
April 25	do	2.91	3
May 5	do	2.91	3
May 19	do	4.05	114
August 6	do	3.70	241
August 8	do	3.50	127
August 11	do	4.00	301
August 24	do	4.35	431
September 5	do	3.51	98
September 19	do	4.70	910
November 13	do	3.90	203
November 21	do	4.82	740
November 23	do	3.78	154
December 13	do	4.90	1,078
December 14	do	5.30	1,773
December 29	do	3.20	84

Daily gage height, in feet, of Tonto Creek near Livingstone, Ariz.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.90	2.95	2.95	2.91	2.91	2.90	2.90	2.90	2.90	2.90	2.90	3.10
2	2.90	2.95	2.95	2.91	2.91	2.90	2.90	2.90	2.90	2.90	2.90	3.10
3	2.90	2.95	2.95	2.91	2.91	2.90	2.90	3.14	2.90	2.90	2.90	3.10
4	2.90	2.95	2.94	2.91	2.91	2.90	2.90	3.00	2.90	2.90	2.90	3.08
5	2.90	2.95	2.94	2.91	2.91	2.90	2.90	2.97	2.90	2.90	2.90	3.07
6	2.90	2.95	2.94	2.91	2.91	2.90	2.90	3.48	2.90	2.90	2.90	3.05
7	2.90	2.95	2.94	2.91	2.91	2.90	2.90	3.00	2.94	2.90	2.90	3.00
8	2.90	2.95	2.94	2.91	2.91	2.90	2.90	4.28	2.92	2.90	2.90	2.95
9	2.90	2.95	2.95	2.91	2.91	2.90	2.90	4.10	2.90	2.90	2.90	2.98
10	2.90	2.95	2.95	2.91	2.91	2.90	2.90	4.30	2.90	2.90	2.90	2.92
11	2.90	2.95	2.95	2.91	2.91	2.90	2.90	3.90	3.05	2.90	3.20	2.92
12	2.90	2.95	2.95	2.91	2.91	2.90	2.90	4.95	2.95	2.90	3.57	2.92
13	2.90	2.95	2.95	2.91	2.91	2.90	2.90	4.40	2.93	2.90	3.85	5.15
14	2.90	2.95	2.91	2.91	2.91	2.90	2.90	3.75	2.90	2.90	3.36	5.20
15	2.90	2.95	2.94	2.91	2.91	2.90	2.90	3.28	3.10	2.90	3.19	4.55
16	2.90	2.85	2.94	2.91	2.91	2.90	2.90	3.00	3.05	2.90	3.07	4.10
17	2.90	2.95	2.94	2.91	2.91	2.90	2.90	2.95	2.98	2.90	2.98	3.90
18	2.90	2.95	2.92	2.91	2.91	2.90	2.90	2.95	2.95	2.90	2.94	3.95
19	2.90	2.95	2.92	2.91	3.61	2.90	2.90	2.93	4.88	2.90	2.92	4.25
20	2.90	2.95	2.92	2.91	2.98	2.90	2.90	2.90	6.45	2.90	2.92	4.10
21	2.90	2.95	2.90	2.91	2.95	2.90	3.53	2.90	5.10	2.90	4.79	3.78
22	2.90	2.95	2.90	2.91	2.95	2.90	5.50	2.90	4.52	2.90	4.58	3.68
23	2.90	2.95	2.90	2.91	2.90	2.90	2.90	2.90	3.90	2.90	3.68	3.55
24	2.90	2.96	2.90	2.91	2.90	2.90	2.90	4.10	3.37	2.90	3.48	3.35
25	2.93	2.93	2.92	2.91	2.90	2.90	2.90	3.90	3.10	2.90	3.44	3.28
26	2.95	2.95	2.91	2.91	2.90	2.90	3.15	3.96	2.97	2.90	3.30	3.24
27	2.95	2.95	2.91	2.91	2.90	2.90	2.90	3.30	2.95	2.90	3.29	3.18
28	2.95	2.95	2.91	2.91	2.90	2.90	2.90	3.10	2.93	2.90	3.25	3.19
29	3.00	.....	2.91	2.91	2.90	2.90	2.90	2.99	2.90	2.90	3.22	3.20
30	3.00	.....	2.91	2.91	2.90	2.90	2.90	2.94	2.90	2.90	3.10	3.10
31	3.00	.....	2.91	.....	2.90	.....	2.90	2.91	.....	2.90	.....	3.00

Estimated monthly discharge of Tonto Creek near Livingstone, Ariz.

[Drainage area, 1,080 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	8.0	2.7	3.3	200	0.003	0.004
February	4.0	2.5	3.0	168	.003	.003
March	2.8	2.3	2.6	159	.002	.003
April	2.6	2.6	2.6	152	.002	.003
May	116.0	2.4	6.3	387	.006	.007
June	2.4	2.4	2.4	146	.002	.003
July	1,708.0	2.4	42.2	2,597	.041	.047
August	1,158.0	2.4	143.7	8,837	.139	.160
September	1,308.0	2.4	138.8	8,258	.134	.150
October	2.4	2.4	2.4	151	.002	.003
November	1,008.0	2.4	93.8	5,583	.091	.102
December	1,408.0	2.6	188.4	11,582	.182	.210
The year	1,708.0	2.3	52.5	38,220	.051	.694

NOTE.—The daily discharges were obtained by interpolation from the measurements.

GILA RIVER AT SAN CARLOS, ARIZ.

The general character of the country through which Gila River flows is a high and rolling plateau, with the river flowing through it in a deep canyon, and with practically no agricultural lands within its area. The river emerges from its upper canyon about 10 miles before it reaches the Arizona line, and thence flows through a valley of considerable width, known as Duncan Valley, until just before it receives the waters of San Francisco River. Duncan Valley in which a number of ditches divert water for irrigation purposes was described at length in the Twenty-first Annual Report.

Gila River is in canyon for about 20 miles below the mouth of the San Francisco, or to within 10 miles of Solomonsville. At this point the hills separate, forming a large valley which has been extensively settled and is now one of the finest irrigated portions of the Territory. This valley extends from a point 10 miles above Solomonsville to 6 miles below the mouth of San Carlos River on the White Mountain Indian Reservation. At this latter place the mountains suddenly close in again and the river enters another canyon. Seven miles below the Indian agency at San Carlos the canyon boxes to a width of 100 feet, and at this point is located the San Carlos dam site,

which was studied by the United States Geological Survey during 1899, in connection with the investigation of the water supply of Gila River. The results of this investigation are published in Water-Supply and Irrigation Paper No. 33, entitled Storage of Water on Gila River, Arizona, by J. B. Lippincott. In connection with this investigation Cyrus C. Babb, on July 11, 1899, established a station on Gila River one-half mile south of the Indian agency at San Carlos and below the mouth of San Carlos Creek. An inclined rod securely fastened to posts driven into the bank was erected here. The bench mark is a 20-penny nail in the base of a mesquite tree 5 inches in diameter, 85 feet west of the gage rod, at an elevation of 12.67 feet above gage datum. Discharge measurements are made from a cable and car a short distance above the gage rod. The channel is straight for some distance above and below the station, and the water is comparatively swift. The right bank is high, but the left is low and liable to overflow. The bed of the stream is sandy and shifting.

Discharge measurements of Gila River at San Carlos, Ariz.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 21	Stephen Janus	1.90	60
January 31	do	1.90	61
February 28	do	1.70	27
March 31	do	(a)	9
Do	do	(a)	9
April 30	do	(a)	5
Do	do	(a)	9
August 7	do	2.50	454
August 15	do	3.20	738
August 22	do	2.50	447
August 26	do	3.40	3,118
September 1	do	2.20	375
September 9	do	1.70	70
September 21	do	2.30	431
September 26	do	1.20	62
October 15	do	(a)	6
November 15	do	(a)	12
December 14	do	3.40	2,485
December 21	do	2.90	1,315
December 31	do	2.20	365

a No water at gage.

Daily gage height, in feet, of Gila River at San Carlos, Ariz.

Day.	Jan.	Feb.	Mar.	July.	Aug.	Sept.	Dec.
1902.							
1	2.00	1.90	1.70	.....	1.00	2.20	.....
2	2.00	1.90	1.70	.....	1.50	2.20	.....
3	2.00	1.90	1.70	.....	1.50	2.10	.....
4	2.00	1.90	1.70	.....	1.50	2.10	.....
5	2.00	1.90	1.70	.....	1.50	2.00	.....
6	2.00	1.90	1.60	.....	1.50	2.00	.....
7	2.00	1.90	1.60	.....	2.45	1.90	.....
8	2.00	1.90	1.60	.....	1.85	1.80	.....
9	2.00	1.90	1.60	.....	1.85	1.70	.....
10	2.00	1.90	1.50	.....	2.10	1.70	.....
11	2.00	1.90	1.50	.....	2.20	1.70	.....
12	2.00	1.90	1.50	.....	2.10	1.70	.....
13	2.00	1.90	1.50	.....	3.35	1.60	.....
14	2.00	1.90	1.45	.....	3.30	1.60	3.5[illegible]
15	2.00	1.88	1.45	.....	3.10	1.60	2.95
16	2.00	1.85	1.45	.....	2.25	1.60	2.8[illegible]
17	2.00	1.85	1.40	.....	2.40	1.60	2.4[illegible]
18	2.00	1.83	1.40	.....	2.40	1.60	2.4[illegible]
19	2.03	1.80	1.40	.....	2.05	1.60	2.8[illegible]
20	1.93	1.80	1.40	.....	1.85	1.60	2.4[illegible]
21	1.90	1.80	.....	.....	1.65	2.15	2.9[illegible]
22	1.90	1.80	.....	2.85	1.50	1.45	2.7[illegible]
23	1.90	1.80	.....	1.95	1.50	1.30	2.7[illegible]
24	1.90	1.75	.....	1.70	3.45	1.30	2.6[illegible]
25	1.90	1.70	.....	1.40	3.65	1.20	2.5[illegible]
26	1.90	1.70	.....	1.45	3.60	1.20	2.4
27	1.90	1.70	.....	.....	2.80	1.10	2.4
28	1.90	1.70	.....	.....	2.90	.....	2.4[illegible]
29	1.90	.....	.....	.....	3.25	.....	2.3[illegible]
30	1.90	.....	.....	.....	2.60	.....	2.3[illegible]
31	1.90	.....	.....	.....	2.30	.....	2.2[illegible]

NOTE.—No water at gage Mar. 23 to July 21, July 27 to 31, Oct. 1 to Dec. 14.

Rating table for Gila River at San Carlos, Ariz., for 1902.

JANUARY 1 to JULY 31.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	8	2.0	115	2.6	780	3.2	2,010
1.5	12	2.1	190	2.7	955	3.3	2,245
1.6	18	2.2	285	2.8	1,130	3.4	2,480
1.7	26	2.3	395	2.9	1,320	3.5	2,715
1.8	40	2.4	515	3.0	1,540	.....	.....
1.9	70	2.5	640	3.1	1,775	.....	.....

Rating table for Gila River at San Carlos, Ariz., for 1902—Continued.

AUGUST 1 TO DECEMBER 31.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	3	1.7	75	2.4	520	3.1	1,775
1.1	6	1.8	108	2.5	640	3.2	2,010
1.2	11	1.9	150	2.6	780	3.3	2,245
1.3	17	2.0	200	2.7	955	3.4	2,480
1.4	25	2.1	260	2.8	1,130	3.5	2,715
1.5	35	2.2	334	2.9	1,320	3.6	2,950
1.6	50	2.3	420	3.0	1,540	.....	.....

Estimated monthly discharge of Gila River at San Carlos, Ariz.

[Drainage area, 13,455 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	152	70	99.51	6,118.6	0.0074	0.0085
February	70	26	55.43	3,078.4	.0041	.0043
March 1–20	.....	.....	[a] 15.60	625.5	.0011	.00082
April	.....	.....	([a])	.....	.....	.....
May	.....	.....	([a])	.....	.....	.....
June	.....	.....	([a])	.....	.....	.....
July 22–26	.....	.....	[a] 118.50	1,308.5	.0089	.0017
August	3,067	3	792.00	48,698.0	.0588	.0670
September 1–27	.....	.....	[a] 108.70	5,821.3	.0080	.0080
October	.....	.....	([a])	.....	.....	.....
November	.....	.....	([a])	.....	.....	.....
December 14–31	.....	.....	[a] 961.00	34,286.1	.0714	.0480

[a] For these portions of the year there was no water at the gage.

ANIMAS RIVER AT DURANGO, COLO.

The station was first established June 20, 1895, and has been maintained during the greater part of each year since.

The original gage was located at the old wagon bridge one-quarter of a mile west of the railroad station at Durango, and about 200 feet above the Rio Grande Southern Railroad bridge. It was spiked to the west side of the south end of the middle pier of the wagon bridge. The head of a bolt at the east abutment of the railroad bridge is 17.24 feet above gage datum. During the early part of 1899 the old wagon

bridge was removed and a new one erected a short distance below. April 1, 1899, on the central pier of this bridge a new rod, which is a vertical piece of timber graduated to feet and tenths, was fastened. The bench marks are three horizontal strips, opposite the 10-, 14-, and 16.7-foot marks of the rod, respectively. Owing to this change in location and height of the rod there is no apparent relation between the rating tables before 1899 and the rating table for 1899 and after. On June 25, 1900, the gage was referred to a new bench mark—a point chiseled on the lower side of the left-hand abutment of the bridge 16.84 feet above the zero of the rod. Lightner Creek enters the river from the right about 100 feet below the bridge. The channel at the station is straight, the bed is of gravel and bowlders, and the banks are sufficiently high that there is little danger of overflow. The observer is C. G. Graden, of Durango.

The following discharge measurements were made during 1902 by A. L. Fellows:

March 20: Gage height 6.15 feet; discharge, 148 second-feet.
July 12: Gage height 6.72 feet; discharge, 302 second-feet.

Daily gage height, in feet, of Animas River at Durango, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	6.10	8.50	9.10	6.80	6.40	6.80	6.90	[illegible]
2	6.10	9.00	8.80	6.80	6.40	6.80	7.00	[illegible]
3	6.10	9.30	8.90	6.80	6.40	6.70	6.90	[illegible]
4	6.20	8.90	9.20	6.80	6.30	6.70	7.00	[illegible]
5	6.40	8.70	8.90	6.80	6.30	6.60	6.60	[illegible]
6	6.50	9.20	8.80	6.80	6.20	6.50	6.50	[illegible]
7	6.60	9.50	8.60	6.80	6.20	6.50	6.40	[illegible]
8	6.60	9.20	8.90	6.80	6.20	6.60	6.50	[illegible]
9	6.70	9.00	8.80	6.80	6.20	6.50	6.50	[illegible]
10	6.90	9.00	8.60	6.80	6.20	6.50	6.70	[illegible]
11	6.90	9.50	8.50	6.70	6.20	6.50	6.50	[illegible]
12	7.00	9.00	8.50	6.70	6.20	6.60	6.50	[illegible]
13	6.90	8.70	8.40	6.70	6.30	6.60	6.50	[illegible]
14	6.90	8.60	8.40	6.60	6.40	6.50	6.40	[illegible]
15	6.80	8.70	8.00	6.60	6.40	6.50	6.40	[illegible]
16	6.80	9.00	7.90	6.60	6.30	6.50	6.50	[illegible]
17	7.10	9.00	7.90	6.60	6.30	6.40	6.50	[illegible]
18	7.00	8.90	7.80	6.50	6.30	6.30	6.50	[illegible]
19	7.20	8.20	7.70	6.50	6.30	6.40	6.50	[illegible]
20	7.50	7.90	7.50	6.50	6.30	6.40	6.50	[illegible]
21	7.50	7.60	7.30	6.50	6.30	7.00	6.50	[illegible]
22	7.40	7.50	7.30	6.50	6.30	6.90	6.50	[illegible]
23	7.60	7.50	7.20	6.50	6.40	6.70	6.50	[illegible]
24	7.00	7.90	7.20	6.40	6.90	7.00	6.50	[illegible]
25	7.00	8.00	7.10	6.40	7.50	7.00	6.50	[illegible]
26	6.90	8.10	7.10	6.40	7.50	7.00	6.50	[illegible]
27	7.10	8.90	7.00	6.40	7.40	7.00	6.50	[illegible]
28	7.30	8.30	7.00	6.40	7.20	6.80	6.50	[illegible]
29	7.70	8.50	6.90	6.40	7.10	6.90	6.50	[illegible]
30	8.30	8.70	6.90	6.40	7.00	6.90	6.50	[illegible]
31	.....	8.40	.....	6.40	6.80	.....	6.50	[illegible]

Rating table for Animas River at Durango, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.6	50	6.4	206	7.2	540	8.0	1,076
5.7	63	6.5	232	7.3	597	8.2	1,244
5.8	80	6.6	263	7.4	655	8.4	1,427
5.9	100	6.7	300	7.5	717	8.6	1,622
6.0	120	6.8	342	7.6	782	8.8	1,829
6.1	140	6.9	387	7.7	850	9.0	2,050
6.2	160	7.0	435	7.8	922	9.2	2,300
6.3	182	7.1	486	7.9	997	9.4	2,590

Estimated monthly discharge of Animas River at Durango, Colo.

[Drainage area, 812 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	1,334	146	445	26,479	0.549	0.61
May	2,750	717	1,699	104,467	2.092	2.41
June	2,300	387	1,179	70,155	1.452	1.62
July	342	206	271	16,663	.334	.38
August	717	160	273	16,786	.336	.39
September	435	182	299	17,792	.368	.41
October	435	206	256	15,741	.315	.36

FLORIDA RIVER NEAR DURANGO, COLO.

During 1899 work was being done on a large storage project near the head of the river, and on this account a gaging station was established by A. L. Fellows May 19, 1899. It is located at a wagon bridge at Stewart's ranch, which is about 6½ miles east of Durango and is reached by driving. The gage rod consists of a vertical 4-inch strip 7½ feet long, graduated to feet and tenths and spiked to the east abutment of the bridge. The bench mark was established April 15, 1901, and consists of a spike in an 8-inch cottonwood stump, 50 feet south from and 5.86 feet above the zero of the rod. Gagings are made at the wagon bridge, except at low water, when they may be made by wading. Information derived at this point is of importance, as it is desired that the excess water of this stream shall be made available by means of storage reservoirs in the upper part of this drainage basin. Much valuable land can be irrigated if this water is properly conserved. The station was discontinued during 1900. The observer is Mrs. Annie Stewart, who lives near by.

The following discharge measurement was made in 1902 by A. L. Fellows:

July 11: Gage height, 0.80 foot; discharge, 11 second-feet.

Daily gage height, in feet, of Florida River near Durango, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	0.80	2.40	1.65	0.90	0.70	0.85	1.0[illegible]
2	.80	2.50	1.50	.95	.65	.80	1.0[illegible]
3	.85	2.45	1.45	.95	.60	.80	1.0[illegible]
4	.90	2.55	1.35	.95	.60	.80	1.0[illegible]
5	.90	2.10	1.20	.90	.60	.80	1.0[illegible]
6	1.00	2.10	1.10	.90	.60	.80	1.0[illegible]
7	1.10	2.20	1.00	.90	.60	.75	1.0[illegible]
8	1.10	2.05	1.05	.85	.60	.70	[illegible]
9	1.15	1.90	.95	.75	.60	.70	.9[illegible]
10	1.15	1.80	.85	.70	.60	.70	.9[illegible]
11	1.30	1.95	.75	.75	.75	.70	.9[illegible]
12	1.40	1.95	.85	.70	.90	.70	.9[illegible]
13	1.35	1.90	.75	.70	.90	.65	.9[illegible]
14	1.35	1.80	.70	.70	.90	.50	.9[illegible]
15	1.15	1.75	.70	.70	.85	.50	.9[illegible]
16	1.30	1.80	.70	.70	.80	.60	.9[illegible]
17	1.50	1.70	.80	.70	.80	.50	.9[illegible]
18	1.65	1.50	.85	.70	.75	.55	.9[illegible]
19	1.95	1.35	.80	.70	.70	.55	.9[illegible]
20	1.90	1.20	.75	.70	.70	.50	.9[illegible]
21	1.85	1.15	.75	.70	.70	1.20	[illegible]
22	1.45	1.15	.75	.70	.70	1.85	[illegible]
23	1.25	1.10	.70	.70	.85	1.70	.7[illegible]
24	1.25	1.30	.80	.75	1.90	1.75	.7[illegible]
25	1.35	1.55	.75	.70	1.75	1.40	.7[illegible]
26	1.55	1.50	.85	.80	1.45	1.25	.6[illegible]
27	1.50	1.95	.85	.75	1.35	1.10	.6[illegible]
28	1.90	1.90	.80	.75	1.20	1.00	.6[illegible]
29	2.05	1.85	.85	.70	1.15	1.00	.6[illegible]
30	2.45	1.70	.80	.70	1.00	1.00	.6[illegible]
31	.....	1.75	.....	.70	1.00	.....	.6[illegible]

Rating table for Florida River near Durango, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	5	1.4	45	2.3	248	3.2	482
.6	7	1.5	56	2.4	274	3.3	508
.7	9	1.6	74	2.5	300	3.4	534
.8	11	1.7	98	2.6	326	3.5	560
.9	15	1.8	122	2.7	352	3.6	586
1.0	19	1.9	146	2.8	378	3.7	612
1.1	24	2.0	170	2.9	404		
1.2	30	2.1	196	3.0	430		
1.3	37	2.2	222	3.1	456		

Estimated monthly discharge of Florida River near Durango, Colo.

[Drainage area, 136 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	287	11	63	3,749	0.46	0.51
May	313	24	134	8,239	.99	1.14
June	86	9	19	1,131	.14	.16
July	17	9	11	676	.08	.09
August	146	7	21	1,291	.15	.17
September	134	5	23	1,369	.17	.19
October	19	7	13	799	.10	.12

LOS PINOS RIVER AT IGNACIO, COLO.

The station was established April 22, 1899, at the request of the Commissioner of Indian Affairs, for the purpose of ascertaining the quantity of water available for irrigation along the stream. It is located at the wagon bridge at Ignacio, the subagency of the Southern Ute Indian Reservation, 2 miles north of the Denver and Rio Grande Railroad station. The rod is a vertical 2 by 4 inch timber, 10 feet long, spiked to the bridge, the marks being strips of brass securely nailed to the post. Bench mark No. 1 is the 8-foot mark on the gage rod, which is level with the top of the lower end of a 6 by 8 inch timber protruding downstream from the pier on the right-hand side. Bench mark No. 2, placed April 7, is an iron bench-mark post set 30 feet northwest from the northwest corner of the bridge, its top being 7.64 feet above the zero of the gage. The observer is John Wesch, the clerk at the agency. The banks are low, but not subject to overflow; the bed of the stream is of gravel, but not liable to radical change.

The following discharge measurements were made during 1902 by A. L. Fellows:

March 27: Gage height, 2.44 feet; discharge, 57 second-feet.
July 11: Gage height, 2.15 feet; discharge, 39 second-feet.

Daily gage height, in feet, of Los Pinos River at Ignacio, Colo.

Day.	Apr.	May.	June.	Day.	Apr.	May.	June.
1902.				1902.			
1	2.40	3.60	3.30	17	3.00	3.35	.....
2	2.40	3.70	3.30	18	3.05	3.35	.....
3	2.40	3.75	3.25	19	3.30	3.35	.....
4	2.40	3.60	3.15	20	3.40	3.35	.....
5	2.40	3.50	3.05	21	3.30	3.25	.....
6	2.45	3.60	3.05	22	3.30	3.25	.....
7	2.70	3.65	3.05	23	3.35	3.25	.....
8	2.80	3.65	3.05	24	3.20	3.35	.....
9	2.85	3.45	3.00	25	3.10	3.35	.....
10	3.00	3.45	2.95	26	3.00	3.25	.....
11	3.10	3.50	2.90	27	3.00	3.25	.....
12	3.00	3.50	2.85	28	3.15	3.35	.....
13	2.95	3.50	2.85	29	3.30	3.35	.....
14	2.95	3.45	2.80	30	3.50	3.40	.....
15	2.90	3.45	(a)	31	.....	3.40	.....
16	2.95	3.35	.....				

[a] No observer available.

Rating table for Los Pinos River at Ignacio, Colo.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	25	2.9	259	3.8	795	4.7	1,352
2.1	32	3.0	315	3.9	856	4.8	1,414
2.2	43	3.1	375	4.0	918	4.9	1,476
2.3	56	3.2	435	4.1	980	5.0	1,538
2.4	73	3.3	495	4.2	1,042	5.1	1,600
2.5	95	3.4	555	4.3	1,104	5.2	1,662
2.6	125	3.5	615	4.4	1,166		
2.7	163	3.6	675	4.5	1,228		
2.8	208	3.7	735	4.6	1,290		

Estimated monthly discharge of Los Pinos River at Ignacio, Colo.

[Drainage area, 450 square miles.]

Month.	Discharge in second-feet.			Total in acre feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	615	73	312	18,565	0.69	0.77
May	765	465	577	35,478	1.28	1.48
June 1–14	.....	.....	341	9,469	.76	.40

DOLORES RIVER AT DOLORES, COLO.

This station was established by F. Cogswell in June, 1895. The gage is located about one-half mile above the railroad station, at the footbridge from which the measurements of discharge are made. The gage is vertical, and is spiked to the crib abutment of the bridge on the left bank. The bench mark consists of a nail driven into the base of a cottonwood tree 18 feet southwest from the gage. This is 1.57 feet above the 14-foot mark. The locality is especially good for accurate measurement, as the bed of the stream is apparently permanent and the banks are not liable to overflow at moderate stages.

The observer is Mary D. Smith.

The following discharge measurement was made in 1902 by A. L. Fellows:

July 14: Gage height, 2.65 feet; discharge, 47 second-feet.

Daily gage height, in feet, of Dolores River at Dolores, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	2.70	4.60	3.95	2.80	2.50	2.80	2.60
2	2.70	4.55	3.85	2.80	2.50	2.80	2.60
3	2.80	4.45	3.75	2.85	2.50	2.75	2.60
4	2.90	4.25	3.75	2.90	2.50	2.70	2.60
5	3.00	4.05	3.70	2.90	2.50	2.65	2.60
6	3.00	4.05	3.70	2.90	2.50	2.60	2.55
7	3.10	4.15	3.55	2.90	2.50	2.60	2.50
8	3.20	4.15	3.55	2.85	2.45	2.60	2.50
9	3.25	4.15	3.50	2.80	2.40	2.60	2.60
10	3.35	4.05	3.45	2.80	2.45	2.55	2.60
11	3.45	4.05	3.40	2.75	2.55	2.50	2.60
12	3.50	4.10	3.40	2.70	2.75	2.50	2.60
13	3.50	3.70	3.40	2.70	2.80	2.50	2.60
14	3.50	4.10	3.40	2.60	2.80	2.50	2.60
15	3.50	4.15	3.25	2.60	2.80	2.50	2.60
16	3.50	4.15	3.20	2.60	2.80	2.50	2.60
17	3.50	4.15	3.20	2.60	2.70	2.60	2.60
18	3.65	3.95	3.15	2.70	2.70	2.60	2.60
19	3.80	3.80	3.00	2.70	2.70	2.60	2.60
20	4.00	3.65	3.00	2.60	2.65	2.65	2.60
21	3.95	3.60	3.00	2.60	2.60	3.00	2.55
22	3.80	3.60	2.95	2.60	2.65	3.15	2.50
23	3.80	3.50	2.90	2.60	2.85	2.95	2.50
24	3.65	3.50	2.90	2.55	3.25	2.90	2.50
25	3.80	3.60	2.90	2.55	3.30	2.90	2.50
26	3.60	3.70	2.90	2.60	3.30	2.85	2.50
27	3.65	4.00	2.90	2.65	3.15	2.80	2.55
28	3.75	4.05	2.90	2.65	3.00	2.75	2.60
29	4.10	4.20	2.90	2.60	3.00	2.75	2.60
30	4.40	4.05	2.90	2.60	3.00	2.70	2.60
31	.....	4.10	.....	2.50	3.00	.....	2.60

Rating table for Dolores River at Dolores, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.4	20	3.0	150	3.6	556	4.2	1,001
2.5	28	3.1	205	3.7	628	4.3	1,078
2.6	37	3.2	271	3.8	700	4.4	1,157
2.7	51	3.3	341	3.9	773	4.5	1,238
2.8	73	3.4	412	4.0	849	4.6	1,323
2.9	106	3.5	484	4.1	925		

Estimated monthly discharge of Dolores River at Dolores, Colo.

[Drainage area, 524 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	1,157	51	497	29,574	0.948	1.05
May	1,323	484	857	52,695	1.635	1.89
June	811	106	342	20,350	.653	.72
July	106	28	56	3,443	.107	.13
August	341	20	92	5,657	.176	.20
September	237	28	62	3,689	.118	.13
October	37	28	34	2,091	.065	.07

GUNNISON RIVER AT WHITEWATER, COLO.

This station was established by J. E. Field April 10, 1902, at a new wagon bridge constructed by the State of Colorado at a point about half a mile above the railroad station at Whitewater, on the Denver and Rio Grande Railroad. During 1895, 1897, and 1901 incomplete series of gage heights were obtained at this point, but the station was not regularly established until 1902. It was intended that this station should take the place of the one formerly maintained on the Gunnison at Grand Junction. The latter station was abandoned on account of inaccuracies that could not be overcome. They were mainly due to the fact that high stages of water in Grand River affected the gage rod in the Gunnison, and that the stream bed was partially filled with great bowlders, making accurate gagings impossible.

Discharge measurements of Gunnison River at Whitewater, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902..		*Feet.*	*Second-feet.*
April 10	J. E. Field	4.60	[a] 2,176
May 26	M. C. Hinderlider	6.10	3,322
July 31	do	3.20	384
August 30	do	4.60	1,230
September 20	G. H. Matthes	3.20	302
November 1	J. E. Field	3.80	622

[a] Sometime during the spring, between April 10 and May 26, a dam was placed across the river about 1¼ miles below the gaging station, which affected the gage heights at the bridge where gage is located. In the latter part of the summer part of the dam went out, thereby again changing the readings of gage rod. No definite conclusions could be arrived at as to the extent to which the river surface at gage rod was affected by the construction and later breaking of the dam. The gaging of April 10 was not used in constructing the rating table.

Daily gage height, in feet, of Gunnison River at Whitewater, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	3.00	6.35	7.60	3.70	3.20	4.45	3.60
2	3.00	7.35	7.50	3.75	3.20	4.35	3.50
3	3.00	7.90	7.15	3.80	3.45	4.25	3.45
4	3.10	8.30	7.00	3.75	3.50	4.00	3.40
5	3.25	8.15	7.00	3.70	3.50	3.85	3.30
6	3.35	8.00	6.95	3.85	3.50	3.80	3.30
7	3.40	8.25	6.85	4.40	3.45	3.70	3.45
8	3.55	8.40	6.80	4.15	3.40	3.70	3.55
9	3.70	8.25	6.90	3.90	3.40	3.60	3.85
10	3.75	8.30	6.75	3.80	3.55	3.60	4.00
11	3.95	8.55	6.60	3.70	3.70	3.60	4.20
12	4.05	8.75	6.45	3.60	3.70	3.50	3.90
13	4.15	8.65	6.30	3.50	3.80	3.50	3.65
14	4.35	8.45	6.40	3.40	3.80	3.40	3.60
15	4.45	8.25	6.15	3.35	3.95	3.50	3.50
16	4.60	8.05	5.85	3.30	4.30	3.60	3.50
17	4.85	8.05	5.65	3.60	3.95	3.70	3.50
18	5.10	7.85	5.55	3.90	3.70	3.75	3.50
19	5.40	7.50	5.35	3.65	3.60	3.60	3.50
20	5.60	6.90	5.05	3.50	3.65	3.65	3.50
21	5.70	6.40	5.00	3.35	3.80	3.80	3.40
22	5.85	6.15	4.90	3.70	3.90	3.90	3.40
23	5.55	5.85	4.60	3.85	3.80	3.90	3.40
24	5.10	5.70	4.45	3.80	3.70	4.60	3.40
25	4.85	5.65	4.35	3.70	3.60	4.90	3.40
26	4.80	6.15	4.15	3.60	3.75	4.40	3.40
27	4.80	6.90	4.00	3.60	3.95	3.70	3.40
28	4.80	8.05	4.00	3.60	4.00	3.70	3.55
29	5.15	7.85	3.95	3.70	4.25	3.60	3.60
30	5.90	7.70	3.80	3.70	4.60	3.60	3.75
31	.....	7.35	.....	3.35	4.50	.....	3.80

Rating table for Gunnison River at Whitewater, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.0	260	4.6	1,169	6.2	3,528	7.8	8,237
3.2	341	4.8	1,359	6.4	3,982	8.0	9,007
3.4	427	5.0	1,571	6.6	4,477	8.2	9,825
3.6	521	5.2	1,815	6.8	5,012	8.4	10,690
3.8	623	5.4	2,091	7.0	5,587	8.6	11,587
4.0	734	5.6	2,399	7.2	6,195	8.8	12,500
4.2	860	5.8	2,739	7.4	6,838		
4.4	1,004	6.0	3,116	7.6	7,515		

Estimated monthly discharge of Gunnison River at Whitewater, Colo.

[Drainage area, 7,868 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	2,922	260	1,219	72,535	0.16	0.18
May	12,271	2,481	7,772	477,885	.99	1.14
June	7,515	623	3,284	195,411	.42	.47
July	1,004	383	570	35,048	.07	.08
August	1,169	341	610	37,507	.08	.09
September	1,461	427	667	39,689	.08	.09
October	860	383	504	30,990	.06	.07

GUNNISON RIVER AT IOLA, COLO.

The Iola station was established in March, 1900, for the purpose of determining the amount of water available for the irrigation project of Uncompahgre Valley. The rod is at a wagon bridge which crosses the river about a quarter of a mile above the Denver and Rio Grande Railroad station at Iola. It consists of a piece of 2-inch by 4-inch timber fastened to the downstream side of the second pier of the bridge from the south end, the zero of the rod being 7.43 feet below the bench mark—a spike in the base of an old post 40 feet south of the southern end of the bridge, on the west side of the road. The chief value of the station is with reference to determining the amount of water available for the proposed canal to the Uncompahgre Valley, although, owing to the fact that a number of streams enter the Gunnison below the station, the results obtained do not show the total

amount available. The channel at this place is wide, and the bed being of gravel and bowlders is not particularly susceptible to change. The banks, though not high, are not subject to overflow. The observer, A. Pomel, postmaster at Iola, telegraphs the gage height daily to the local forecast official of the United States Weather Bureau at Denver, who has it printed in the morning papers.

During 1902 the following discharge measurements were made by M. C. Hinderlider and A. L. Fellows:

May 30: Gage height, 3.60 feet; discharge, 1,925 second-feet.
July 19: Gage height, 1.90 feet; discharge, 271 second-feet.
September 1: Gage height, 2.10 feet; discharge, 400 second-feet.

Daily gage height, in feet, of Gunnison River at Iola, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	2.20	3.00	3.70	2.00	1.80	2.00	1.80	2.00
2	2.30	3.20	3.60	2.00	1.80	2.00	1.80	2.00
3	2.30	3.40	3.20	2.00	1.80	2.00	1.90	2.00
4	2.50	3.40	3.20	2.00	1.80	1.90	2.00	2.00
5	2.60	3.60	3.30	2.00	1.80	1.90	2.00	2.00
6	2.70	3.70	3.20	2.30	1.80	1.90	2.00	2.00
7	2.70	3.60	3.20	2.10	1.80	1.90	2.00	2.00
8	2.60	3.80	3.20	2.00	1.80	1.90	1.90	2.00
9	2.60	3.80	3.10	2.00	1.80	1.80	2.00	2.00
10	2.60	4.00	3.00	1.90	1.80	1.80	2.00	2.00
11	2.50	4.00	3.00	1.90	1.80	1.80	2.00	2.10
12	2.50	4.00	3.00	2.00	1.80	1.80	2.00	2.10
13	2.40	3.90	3.00	1.80	1.90	1.80	2.00	2.20
14	2.30	3.90	3.00	1.80	1.90	1.80	2.00	2.20
15	2.30	3.80	2.90	1.80	1.90	1.80	1.90	2.20
16	2.40	3.80	2.80	1.80	1.90	1.80	1.90	2.20
17	2.50	3.80	2.70	1.80	1.90	1.80	1.90	2.20
18	2.60	3.60	2.60	1.80	1.90	1.80	1.90	2.10
19	2.70	3.20	2.60	1.80	1.90	1.80	2.00	2.10
20	2.70	3.00	2.50	1.80	1.80	1.80	2.00	2.20
21	2.70	2.90	2.50	1.80	1.80	1.90	2.00	2.20
22	2.60	2.80	2.40	1.80	1.80	1.90	2.00	2.20
23	2.60	2.80	2.30	1.80	1.90	1.80	2.00	2.10
24	2.50	2.80	2.20	1.80	1.90	1.80	2.00	2.10
25	2.50	3.00	2.20	1.80	2.00	1.80	2.00	2.10
26	2.50	3.20	2.10	1.80	2.10	1.80	2.00	2.20
27	2.60	3.80	2.00	1.80	2.10	1.80	2.00	2.20
28	2.80	3.60	2.00	1.80	2.10	1.80	2.00	2.20
29	2.11	3.60	2.00	1.80	2.10	1.80	2.00	2.20
30	3.00	3.60	2.00	1.80	2.10	1.80	2.00	.....
31	.....	3.60	.....	1.80	2.10	.....	2.00	.....

Rating table for Gunnison River at Iola, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.8	221	2.4	640	3.0	1,205	3.6	1,925
1.9	271	2.5	728	3.1	1,308	3.7	2,090
2.0	330	2.6	818	3.2	1,413	3.8	2,264
2.1	398	2.7	910	3.3	1,522	3.9	2,446
2.2	474	2.8	1,005	3.4	1,638	4.0	2,636
2.3	555	2.9	1,104	3.5	1,772		

Estimated monthly discharge of Gunnison River at Iola, Colo.

[Drainage area, 2,296 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	1,205	402	759	45,164	0.33	0.37
May	2,636	1,005	1,838	113,015	.80	.92
June	2,090	330	997	59,326	.43	.48
July	555	221	269	16,540	.12	.14
August	398	221	273	16,786	.12	.14
September	330	221	244	14,519	.11	.12
October	330	221	312	19,184	.14	.16
November	474	330	408	24,278	.18	.20

GRAND RIVER NEAR PALISADES, COLO.

This station was established April 9, 1902, by John E. Field, at the iron wagon bridge across Grand River where the river enters Grand Valley about 2 miles above Palisades. The channel at this point is deep and rocky, the mountains rising on either side rather abruptly. The station is above all irrigating ditches supplying water to the land of Grand Valley with the exception of one pumping plant, which takes about 20 second-feet of water from the river one-fourth of a mile above the station. The river at this point is deep and at high water very swift. The right bank is high and precipitous; the left bank for a short distance below the bridge is liable to overflow for a short distance out during very high water. The bed of the river is somewhat changeable, but for a river of this size fairly satisfactory results are obtained. The gage consists of a wire cable, to which a window weight is attached, swung from the middle of the bridge. The graduations are painted in feet and tenths on the hub rail on the

bridge. No bench mark has ever been established. The observations have been taken twice daily during the irrigating season since the station was established by S. L. Purdy, pumpman at the Mount Lincoln pumping plant.

Discharge measurements of Grand River near Palisades, Colo.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 9	J. E. Field	12.30	2,564
May 27	M. C. Hinderlider	16.30	9,778
July 30	do	12.20	1,966
August 29	do	12.00	1,662
October 2	G. H. Matthes	12.15	1,415
October 15	do	12.20	1,465
October 26	do	12.20	1,361
November 3	do	12.10	1,346

Daily gage height, in feet, of Grand River near Palisades, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	11.60	14.15	17.75	13.75	12.25	12.00	12.10	(a)
2	11.60	15.00	17.55	13.75	11.98	12.00	12.20	.....
3	11.60	15.75	17.25	13.55	11.95	12.00	12.27	.....
4	11.60	16.30	17.10	13.42	11.92	11.95	12.25	.....
5	11.60	16.65	17.10	13.42	11.92	11.88	12.25	.....
6	11.70	16.90	17.10	13.38	11.90	11.80	12.20	.....
7	11.70	17.05	17.00	13.35	11.82	11.80	12.25	.....
8	12.30	17.30	16.95	13.25	11.80	11.75	12.18	.....
9	12.30	17.50	17.00	13.15	11.80	11.72	12.12	.....
10	12.40	17.75	16.95	12.98	11.75	11.72	12.10	.....
11	12.35	18.30	16.80	12.85	12.08	11.68	12.10	.....
12	12.35	18.45	16.65	12.70	11.80	11.60	12.10	.....
13	12.30	18.20	16.55	12.68	11.75	11.60	12.25	.....
14	12.35	18.30	16.45	12.70	11.75	11.60	12.30	.....
15	12.30	18.45	16.15	12.68	11.85	11.60	12.20	.....
16	12.20	18.55	15.95	12.60	11.98	11.60	12.25	.....
17	12.20	18.60	15.75	12.95	12.00	11.60	12.25	.....
18	12.25	18.25	15.45	12.68	11.48	11.60	12.25	.....
19	12.38	17.85	15.25	12.72	11.85	11.75	12.25	.....
20	12.65	17.10	14.95	13.25	11.78	11.70	12.20	.....
21	12.95	16.55	14.75	12.98	11.72	12.35	12.20	.....
22	13.27	16.00	14.55	12.75	11.70	12.15	12.20	.....
23	13.30	15.55	14.42	12.58	11.70	12.10	12.18	.....
24	12.95	15.30	14.38	12.45	11.65	12.10	12.20	.....
25	12.72	15.25	14.30	12.40	11.78	12.10	12.20	.....
26	12.72	15.75	14.08	12.32	11.85	12.10	12.18	.....
27	12.62	15.65	13.95	12.30	12.00	12.10	12.20	.....
28	12.72	17.45	13.80	12.28	11.60	12.10	12.18	.....
29	13.05	17.20	13.70	12.22	12.00	12.10	12.18	.....
30	13.55	17.30	13.65	12.18	12.10	12.10	12.10	.....
31	.....	17.55	.....	12.12	12.00	.....	12.10	.....

[a] Station closed for winter.

Rating table for Grand River near Palisades, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
11.6	1,102	13.4	3,955	15.2	7,444	17.0	11,542
11.8	1,376	13.6	4,323	15.4	7,867	17.2	12,082
12.0	1,662	13.8	4,698	15.6	8,311	17.4	12,624
12.2	1,960	14.0	5,079	15.8	8,756	17.6	13,171
12.4	2,268	14.2	5,464	16.0	9,204	17.8	13,722
12.6	2,584	14.4	5,853	16.2	9,654	18.0	14,282
12.8	2,911	14.6	6,246	16.4	10,106	18.2	14,876
13.0	3,248	14.8	6,642	16.6	10,562	18.4	15,518
13.2	3,596	15.0	7,041	16.8	11,029	18.6	16,208

Estimated monthly discharge of Grand River near Palisades, Colo.

[Drainage area, 8,546 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	4,230	1,102	2,230	132,694	0.26	0.29
May	16,208	5,367	11,800	725,554	1.38	1.59
June	13,584	4,416	8,873	527,980	1.04	1.16
July	4,604	1,839	3,024	185,939	.35	.40
August	2,036	944	1,479	90,941	.17	.20
September	2,190	1,102	1,489	88,602	.17	.19
October	2,113	1,809	1,951	119,963	.23	.26

GRAND RIVER AT GLENWOOD SPRINGS, COLO.

This station was first located May 12, 1899, at the request of the Denver and Rio Grande Railroad Company, at the railroad bridge a quarter of a mile west of the depot and just above the mouth of Roaring Fork. A wire gage was used. At the beginning of 1900, however, a new gage rod was located near the electric-light works of the Colorado Hotel. Measurements are made from the wagon bridge crossing the river between the town and the hotel. The channel is good, being composed of gravel and rock, and does not change much; the banks are high and not subject to overflow.

During 1902 the following discharge measurements were made by J. E. Field and M. C. Hinderlider.

April 11: Gage height, 3.87 feet; discharge, 1,328 second-feet.
July 28: Gage height, 3.90 feet; discharge, 1,414 second-feet.
August 28: Gage height, 3.60 feet; discharge, 1,079 second-feet.
November 3: Gage height, 3.30 feet; discharge, 842 second-feet.
December 13: Gage height, 3.30 feet; discharge, 775 second-feet.

Daily gage height, in feet, of Grand River at Glenwood Springs, Colo.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.[a]	Dec.
1902.									
1	3.10	3.10	3.25	3.15	5.40	7.75	5.00	.....	.....
2	3.15	3.00	3.20	3.20	5.95	7.65	4.80	.....	.....
3	3.15	2.90	3.20	3.25	6.45	7.40	4.75	.....	2.90
4	3.35	3.00	3.15	3.30	6.75	7.20	4.70	.....	2.90
5	3.25	3.05	3.15	3.40	6.90	7.35	4.60	.....	3.10
6	3.20	3.20	3.25	3.50	6.90	7.30	4.60	.....	3.20
7	3.20	3.20	3.20	3.60	6.70	7.30	4.60	.....	3.20
8	3.20	3.20	3.15	3.70	7.20	7.30	4.45	.....	3.10
9	3.20	3.20	3.25	3.90	7.40	7.40	4.30	.....	3.25
10	3.15	3.20	3.25	3.90	7.50	7.35	4.20	.....	3.25
11	3.10	3.20	3.25	3.85	7.80	7.30	4.20	.....	3.30
12	3.00	3.25	3.25	3.85	7.95	7.15	4.15	.....	3.30
13	3.05	3.30	3.25	3.90	7.80	7.00	4.10	.....	3.30
14	3.10	3.15	3.25	3.90	7.90	6.90	4.10	.....	3.30
15	3.00	3.15	3.15	3.80	8.10	6.65	4.00	.....	3.05
16	3.05	3.30	3.10	3.70	8.20	6.50	4.00	.....	2.85
17	3.20	3.25	3.20	3.70	8.15	6.30	4.00	.....	2.80
18	3.15	3.25	3.25	3.80	7.95	6.10	4.15	.....	2.58
19	3.10	3.30	3.30	3.95	7.75	5.95	4.55	.....	3.05
20	3.15	3.20	3.30	4.15	7.25	5.80	4.60	.....	3.05
21	3.10	3.20	3.35	4.30	6.80	5.60	4.35	.....	3.05
22	2.90	3.30	3.35	4.65	6.35	5.50	4.20	.....	3.05
23	3.20	3.30	3.30	4.45	6.10	5.35	4.10	.....	2.95
24	3.05	3.20	3.30	4.20	5.95	5.35	4.00	.....	3.05
25	3.15	3.30	3.30	4.10	5.95	5.20	3.90	.....	3.25
26	3.05	3.30	3.30	4.10	6.30	5.10	3.90	.....	3.30
27	3.00	3.30	3.30	4.10	7.10	5.10	3.80	.....	3.23
28	2.95	3.20	3.30	4.25	7.50	5.00	.....	.....	3.28
29	3.10	.....	3.25	4.55	7.35	4.90	.....	.....	(b)
30	3.10	.....	3.15	4.90	7.45	4.95	.....	.....	(b)
31	3.10	.....	3.15	.....	7.65	.....	.....	.....	(b)

[a] Automatic register placed on July 28. Never worked satisfactorily. Cause of break in record.

[b] Wire on gage broken.

Rating table for Grand River at Glenwood Springs, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.0	650	4.4	1,969	5.8	5,109	7.2	9,996
3.2	775	4.6	2,242	6.0	5,769	7.4	10,763
3.4	920	4.8	2,584	6.2	6,430	7.6	11,546
3.6	1,079	5.0	2,968	6.4	7,104	7.8	12,340
3.8	1,266	5.2	3,392	6.6	7,800	8.0	13,154
4.0	1,485	5.4	3,881	6.8	8,522	8.2	13,980
4.2	1,722	5.6	4,466	7.0	9,254		

Estimated monthly discharge of Grand River at Glenwood Springs, Colo.

[Drainage area, 5,838 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	882	600	721	44,332	0.123	0.14
February	845	600	775	43,041	.133	.14
March	882	710	802	49,313	.138	.16
April	2,772	742	1,419	84,436	.244	.27
May	13,980	3,881	9,825	604,120	1.683	1.94
June	12,140	2,772	7,316	435,332	1.253	1.39
July 1 to 27	.....	.....	1,864	99,824	.321	.37
December 3 to 28	.....	.....	723	37,285	.124	.13

WHITE RIVER AT MEEKER, COLO.

This station was established by A. L. Fellows, May 24, 1901, about one-half of a mile above the town of Meeker, at a point where a wagon bridge crosses the stream on the ranch of L. F. Van Cleave. The gage rod consists of a vertical 2 by 4 inch timber nailed to the left abutment of the bridge on the downstream side. The bridge is marked every 5 feet. The initial point for soundings is at the rod at the left or south end of the bridge. The banks are so high that they are not liable to overflow; the channel is of rock and gravel, and seems permanent in its nature. Measurements are made from the lower side of the wagon bridge. The observer is L. F. Van Cleave, who reads the rod twice each day.

The following discharge measurements were made during 1902 by A. J. McCune and J. E. Field:

July 6: Gage height, 4.00 feet; discharge, 472 second-feet.
Oct. 17: Gage height, 2.55 feet; discharge, 342 second-feet.

Daily gage height, in feet, of White River at Meeker, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.							
1	3.55	4.70	5.40	3.85	3.30	3.60	3.60
2	3.55	4.85	5.35	3.95	3.35	3.55	3.60
3	3.50	5.20	5.15	3.90	3.35	3.55	3.50
4	3.60	5.25	5.20	3.80	3.35	3.50	3.50
5	3.60	5.25	5.25	3.95	3.35	3.50	3.50
6	3.60	5.30	5.10	4.05	3.35	3.50	3.50
7	3.70	5.50	5.10	3.95	3.35	3.50	3.50
8	3.80	5.65	5.00	3.90	3.35	3.50	3.50
9	3.75	5.75	4.95	3.85	3.30	3.50	3.50
10	3.70	5.70	4.90	3.80	3.30	3.40	3.50
11	3.65	5.80	4.80	3.80	3.30	3.40	3.50
12	3.70	5.70	4.95	3.75	3.40	3.50	3.70
13	3.70	5.65	4.65	3.75	3.40	3.45	3.65
14	3.60	5.70	4.65	3.70	3.45	3.45	3.55
15	3.55	5.70	4.55	3.65	3.40	3.50	3.55
16	3.60	5.70	4.45	3.60	3.40	3.50	3.50
17	3.70	5.70	4.30	3.70	3.40	3.45	3.50
18	3.75	5.60	4.25	3.80	3.40	3.45	3.50
19	3.95	5.25	4.20	3.70	3.40	3.50	3.50
20	4.05	5.10	4.10	3.65	3.40	3.50	3.50
21	4.15	4.85	4.10	3.60	3.40	3.70	3.50
22	4.00	4.75	3.95	3.60	3.40	3.70	3.50
23	3.95	4.70	3.95	3.55	3.40	3.60	3.55
24	3.85	4.60	3.90	3.50	3.45	3.60	3.50
25	3.80	4.60	3.80	3.50	3.50	3.60	3.50
26	3.80	4.90	3.80	3.50	3.50	3.60	3.50
27	3.80	5.15	3.75	3.50	3.50	3.60	3.50
28	4.00	5.30	3.75	3.50	3.50	3.60	3.50
29	4.20	5.35	3.90	3.40	3.50	3.60	3.50
30	4.45	5.25	3.90	3.40	3.50	3.60	3.50
31	.....	5.60	.....	3.30	3.50	.....	3.50

Rating table for White River at Meeker, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.7	300	3.4	372	4.2	523	5.6	2,614
2.8	308	3.5	384	4.4	594	5.8	3,284
2.9	317	3.6	397	4.6	696	6.0	4,034
3.0	327	3.7	412	4.8	845	6.2	4,834
3.1	337	3.8	429	5.0	1,100	6.4	5,634
3.2	348	3.9	448	5.2	1,514		
3.3	360	4.0	469	5.4	2,024		

Estimated monthly discharge of White River at Meeker, Colo.

[Drainage area, 684 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	616	384	433	25,765	0.68	0.75
May	3,284	696	1,927	118,487	3.04	3.50
June	2,024	420	843	50,162	1.33	1.48
July	481	360	414	25,456	.65	.75
August	384	360	372	22,873	.59	.68
September	412	372	389	23,147	.61	.68
October	412	384	387	23,796	.61	.70

UINTA RIVER AT OURAY SCHOOL, NEAR LELAND, UTAH.

This station was established November 8, 1899, and is located at the highway bridge over the river near the Ouray School. It is about 5 miles below the station at Fort Duchesne. Dry Gulch Creek enters from the west, and except during flood stages carries practically only the waste water of Canal No. 1 and the Bench ditch, thereby accounting for the increase in flow between this point and the Fort Duchesne station. The rod is nailed to the east end of the south crib of the wagon bridge. Bench mark No. 1 is the head of a nail in the extreme northeast corner of the bridge floor, and is at an elevation of 4,745.97 feet above sea; bench mark No. 2 is a nail in the flagstaff of the school, with an elevation of 4,760 feet. The elevation of the zero of the rod is 4,737.36 feet. During low water measurements are made by wading, at a section 200 feet below the bridge, and at high stages they are made from the bridge itself. The section is a good one, although the center pier of the bridge will interfere somewhat with the accuracy of the results when measurements are taken there.

Discharge measurements of Uinta River at Ouray School, near Leland, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 27	C. T. Prall	0.56	122
April 5	do	.36	89
April 10	do	.31	81
April 17	do	.24	72
April 24	do	.39	95
May 1	do	.35	90
May 8	do	.69	144
May 15	do	2.65	919
May 22	do	1.60	397
May 29	do	3.50	2,224
June 5	do	2.85	1,143
June 12	do	2.32	732
June 18	do	1.70	426
June 26	do	1.20	285
July 3	do	1.22	278
July 10	do	.67	150
July 24	H. S. Reed	.24	75
July 31	do	.03	47
August 7	do	— .16	35
August 14	do	.03	51
August 21	do	— .12	36
August 28	do	.05	48
September 4	do	.06	52
September 11	do	— .08	35
September 18	do	.07	50
September 25	do	.33	81
October 2	do	.30	78
October 9	do	.33	84
October 23	do	.33	81
October 30	do	.40	87
November 7	do	.33	83
November 13	do	.60	119
November 20	do	.54	109
November 26	do	.15	60
December 4	do	.33	57
December 10	do	.63	104
December 19	do	.65	89

Daily gage height, in feet, of Uinta River at Ouray School, near Leland, Utah, for 1902.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	(a)	(a)	0.46	0.31	3.45	1.28	0.01	0.19	0.30	0.40	[illegible]
2				.36	.32	3.05	1.39	− .04	.15	.30	.50	[illegible]
3				.38	.31	2.60	1.20	− .08	.11	.30	.40	[illegible]
4				.38	.35	2.50	1.18	− .09	.08	.30	.38	[illegible]
5				.36	.32	2.55	1.10	− .06	.01	.31	.40	[illegible]
6				.38	.45	2.60	1.10	− .12	− .01	.33	.35	[illegible]
7				.35	.51	2.60	1.00	− .14	− .02	.34	.35	[illegible]
8				.40	.70	2.68	.85	− .17	− .03	.35	.37	[illegible]
9				.40	.88	2.68	.70	− .19	− .03	.35	.39	[illegible]
10				.38	1.33	2.50	.68	− .21	− .04	.34	.40	[illegible]
11				.32	1.90	2.54	.60	− .23	− .06	.35		[illegible]
12				.35	2.24	2.40	.59	.00	− .08	.35	.72	[illegible]
13				.38	2.35	2.20	.55	.05	− .09	.37	.63	[illegible]
14				.31	2.50	2.10	.45	.01	− .11	.38	.45	[illegible]
15				.31	2.75	2.00	.39	.06	− .11	.38	.50	[illegible]
16				.27	2.55	1.85	.38	.07	.00	.38	.38	[illegible]
17				.28	2.90	1.74	.40	− .01	.05	.37	.35	[illegible]
18				.26	2.53	1.68	.48	− .05	.06	.35	.43	[illegible]
19				.29	2.30	1.53	.40	− .12	.07	.35	.32	[illegible]
20				.30	1.96	1.48	.36	− .08	.07	.38	.53	[illegible]
21				.45	1.80	1.48	.32	− .02	1.80	.38	.51	[illegible]
22				.68	1.59	1.40	.28	− .13	.58	.36	.52	[illegible]
23				.41	1.48	1.32	.28	− .14	.40	.35	.52	[illegible]
24				.45	1.30	1.28	.25	− .15	.36	.33	.50	[illegible]
25				.40	1.44	1.24	.20	− .12	.32	.33	.45	[illegible]
26				.38	1.85	1.20	.20	− .10	.30	.33	.40	[illegible]
27				.38	2.95	1.12	.15	− .11	.30	.35	.40	[illegible]
28				.35	3.53	1.18	.12	.01	.30	.33	.42	[illegible]
29				.32	3.75	1.50	.11	.18	.31	.38	.40	[illegible]
30				.29	3.78	1.35	.08	.18	.30	.38	.40	[illegible]
31					3.60		.05	.17		.38		[illegible]

[a] River frozen.

Rating table for Uinta River at Ouray School, near Leland, Utah, for January 1 to December 1, 1902.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.2	30	1.0	210	2.2	660	3.4	2,040
− .1	35	1.1	240	2.3	720	3.5	2,200
.0	40	1.2	270	2.4	780	3.6	2,362
.1	54	1.3	300	2.5	850	3.7	2,524
.2	68	1.4	330	2.6	930	3.8	2,686
.3	82	1.5	360	2.7	1,010	3.9	2,848
.4	96	1.6	390	2.8	1,110	4.0	3,010
.5	110	1.7	430	2.9	1,240	4.1	3,172
.6	130	1.8	470	3.0	1,400	4.2	3,334
.7	150	1.9	510	3.1	1,560	4.3	3,496
.8	170	2.0	550	3.2	1,720	4.4	3,658
.9	190	2.1	600	3.3	1,880	4.5	3,820

[a] The daily discharges for December were obtained from the measurements by interpolation.

Estimated monthly discharge of Uinta River at Ouray School, near Leland, Utah.

[Drainage area, 967 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January [a]			110	6,764	0.11	0.13
February [a]			110	6,109	.11	.11
March [a]			100	6,149	.10	.12
April	146	76	92	5,457	.09	.10
May	2,653	84	740	45,484	.77	.89
June	2,120	246	651	39,029	.67	.75
July	327	47	132	8,148	.14	.16
August	65	30	40	2,467	.04	.05
September	470	34	72	4,284	.07	.08
October	94	78	89	5,460	.09	.10
November	154	57	97	5,780	.10	.11
December [a]	104	57	83	5,129	.09	.10
The year	2,653	30	193	140,296	.20	2.70

[a] Jan. 1 to Apr. 1, and Dec. 21-31, river frozen; quantities estimated.

DUCHESNE RIVER AT PRICE ROAD BRIDGE, UTAH.

The station on Duchesne River was established October 26, 1899, and is located 3 miles below the mouth of Lake Creek at the highway bridge on the stage road from Price to Fort Duchesne. The permanent gage rod was placed November 16, 1899, and is nailed to the east side of the center pier. Bench mark No. 1 is a wire nail in a log close to the rod, and is opposite the 7-foot mark. Bench mark No. 2 is a wire nail on the west side of the crib, with an elevation of 5.48 feet above gage datum. The section at this point is very good, with a moderate velocity of water. There is one pier in the center of the stream which does not materially affect the accuracy of the results at low water, but presumably will to a certain extent during the flood season.

Discharge measurements of Duchesne River at Price Road Bridge, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 21	C. T. Prall	5.23	294
March 28	do	5.25	307
April 4	do	5.32	331
April 11	do	5.56	438
April 18	do	6.28	1,065
April 25	do	5.93	665
May 2	do	6.05	820
May 9	do	6.45	1,157
May 16	do	7.50	2,357
May 23	do	6.75	1,402
May 30	do	8.85	5,011
June 6	do	8.30	3,750
June 13	do	7.55	2,484
June 20	do	6.70	1,329
June 27	do	6.20	926
July 5	do	6.08	820
July 11	Prall and Reed	5.75	572
July 19	H. S. Reed	5.50	435
July 25	do	5.40	389
August 1	do	5.22	284
August 9	do	5.12	242
August 15	do	5.35	361
August 22	do	5.15	225
August 29	do	5.22	274
September 5	do	5.02	194
September 12	do	5.00	189
September 19	do	5.10	222
September 26	do	5.22	250
October 3	do	5.22	277
October 10	do	5.22	261
October 18	do	5.25	273
October 24	do	5.25	283
October 31	do	5.25	264
November 14	do	5.28	268
November 21	do	5.30	296
November 28	do	5.35	309

Daily gage height, in feet, of Duchesne River at Price Road Bridge, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	(a)	(a)	(a)	5.26	6.05	8.80	6.10	5.20	5.13	5.25	5.28	(a)
2				5.27	6.13	8.25	6.13	5.15	5.10	5.25	5.28	
3				5.29	6.18	7.90	6.13	5.18	5.10	5.25	5.28	
4				5.30	6.21	7.90	6.14	5.18	5.10	5.25	5.28	
5				5.33	6.22	8.05	6.09	5.15	5.10	5.25	5.28	
6				5.38	6.24	8.10	6.07	5.13	5.10	5.20	5.28	
7				5.39	6.25	8.15	6.03	5.13	5.08	5.20	5.28	
8				5.47	6.28	8.25	5.88	5.13	5.00	5.20	5.29	
9				5.53	6.48	8.43	5.80	5.10	5.00	5.20	5.28	
10				5.56	6.63	8.45	5.75	5.13	4.96	5.20	5.28	
11			5.19	5.58	6.80	7.85	5.75	5.15	4.99	5.20	5.30	
12			5.20	5.60	7.04	7.60	5.73	5.18	5.00	5.20	5.30	
13			5.23	5.63	7.35	7.45	5.70	5.20	5.02	5.20	5.30	
14			5.21	5.70	7.33	7.38	5.68	5.45	5.05	5.20	5.30	
15			5.25	5.78	7.48	7.35	5.65	5.33	5.05	5.20	5.30	
16			5.27	5.85	7.50	7.10	5.65	5.25	5.08	5.20	5.30	
17			5.27	5.93	7.60	6.90	5.64	5.18	5.10	5.25	5.30	
18			5.26	6.30	7.63	6.75	5.60	5.18	5.10	5.25	5.30	
19			5.27	6.46	7.40	6.65	5.50	5.18	5.10	5.25	5.30	
20			5.28	6.64	7.25	6.68	5.50	5.18	5.10	5.25	5.32	
21			5.21	6.50	7.00	6.57	5.50	5.18	5.38	5.25	5.32	
22			5.21	6.21	6.83	6.55	5.50	5.15	5.39	5.28	5.32	
23			5.22	5.95	6.70	6.53	5.46	5.15	5.33	5.29	5.32	
24			5.22	5.90	6.65	6.50	5.42	5.15	5.35	5.30	5.32	
25			5.23	5.93	6.55	6.40	5.40	5.15	5.28	5.30	5.32	
26			5.24	6.00	6.80	6.31	5.40	5.15	5.25	5.28	5.32	
27			5.25	6.04	7.50	6.20	5.35	5.15	5.25	5.28	5.32	
28			5.25	6.08	7.88	6.19	5.33	5.18	5.25	5.28	5.32	
29			5.26	5.99	8.53	6.18	5.28	5.20	5.25	5.28	5.32	
30			5.24	6.05	8.80	6.14	5.25	5.20	5.25	5.28	5.32	
31			5.27		9.20		5.23	5.17		5.28		

[a] River frozen.

Rating table for Duchesne River at Price Road Bridge, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.0	200	6.4	1,120	7.8	2,840	9.2	5,820
5.2	280	6.6	1,320	8.0	3,160	9.4	6,280
5.4	380	6.8	1,520	8.2	3,550	9.6	6,740
5.6	500	7.0	1,760	8.4	3,980	9.8	7,200
5.8	630	7.2	2,000	8.6	4,440	10.0	7,660
6.0	780	7.4	2,240	8.8	4,900		
6.2	940	7.6	2,520	9.0	5,360		

Estimated monthly discharge of Duchesne River at Price Road Bridge, Utah.

[Drainage area, 2,746 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January [a]	----------	----------	280	17,217	0.10	0.12
February [a]	----------	----------	280	15,550	.10	.11
March [a]	----------	----------	291	17,875	.11	.13
April	1,360	304	656	39,035	.24	.27
May	5,820	820	1,969	121,069	.72	.83
June	4,900	892	2,239	133,235	.82	.91
July	892	292	555	34,138	.20	.23
August	410	240	273	16,804	.10	.12
September	374	184	258	15,364	.09	.10
October	320	280	297	18,288	.11	.13
November	332	312	322	19,152	.12	.13
December [a]	----------	----------	300	18,447	.11	.13
The year	5,820	184	644	466,174	.24	3.21

[a] Jan. 1 to Mar. 10 and Dec. 1-31 river frozen; quantities estimated.

LAKE CREEK AT WAGON BRIDGE (NEAR MOUTH), UTAH.

The permanent gage rod at this place consists of a 1-inch by 4-inch by 8-foot board nailed vertically to the west abutment on the lower side of the wagon bridge near the mouth of the creek. Bench mark No. 1 is a nail in the abutment opposite the 4.50-foot mark on the rod. Bench mark No. 2 is directly over the gage rod, and is the head of a wire nail in the southwest corner of the bridge upright. Its elevation is 5,066.58 feet. The elevation of the zero of the rod is 5,055.99 feet above sea level, according to the hydrographic survey datum. The elevation of bench mark No. 2 is 5,129 feet, referred to the topographic survey datum. The elevation of a regulation iron post bench mark, 150 feet east of the bridge, is 5,127.55 feet, referred to the latter datum. The bed of the stream is composed of medium-sized cobblestones and forms a fair section. During flood stages measurements are made from the bridge, but at other periods they are made by wading at a point about 400 feet below.

Discharge measurements of Lake Creek at wagon bridge (near mouth), Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 21	C. T. Prall	1.86	93
March 28	do	1.92	103
April 4	do	1.92	105
April 11	do	1.90	103
April 18	do	1.90	103
April 25	do	2.00	121
May 2	do	2.04	133
May 9	do	2.33	226
May 16	do	3.20	651
May 23	do	2.70	358
May 30	do	5.85	2,367
June 6	do	4.93	1,735
June 13	do	4.10	1,144
June 20	do	3.10	649
June 27	do	2.70	454
July 5	do	2.55	357
July 11	Prall and Reed	2.30	222
July 19	H. S. Reed	2.25	173
July 25	do	2.05	141
August 1	do	1.95	106
August 9	do	1.92	98
August 15	do	2.06	141
August 22	do	1.89	89
August 29	do	1.93	110
September 5	do	1.80	79
September 12	do	1.80	76
September 19	do	1.85	86
September 26	do	1.95	105
October 3	do	1.92	103
October 10	do	1.90	94
October 24	do	1.92	99
October 31	do	1.90	96
November 14	do	1.90	98
November 21	do	1.93	97
November 28	do	2.50	127
November 28	do	2.50	162
December 5	do	2.00	106
December 13	do	1.82	76

Daily gage height, in feet, of Lake Creek at wagon bridge (near mouth), Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	(a)	(a)	(a)					1.95				
2					2.04							
3										1.92		
4				1.92								
5							2.55		1.80			2.00
6						4.93						
7												
8											1.89	
9					2.33			1.92				
10										1.90		
11				1.90			2.30					
12									1.80			
13						4.10						1.82
14											1.90	(a)
15								2.06				
16					3.20							
17												
18				1.90								
19							2.25		1.85			
20			(a)			3.10						
21			1.86								1.93	
22								1.89				
23					2.70							
24										1.92		
25				2.00			2.05					
26									1.95			
27						2.70						
28			1.92								2.50	
29								1.93				
30					5.85							
31										1.90		

a River frozen.

Estimated monthly discharge of Lake Creek at wagon bridge.

[Drainage area, 475 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January [a]			90	5,534	0.19	0.22
February [a]			90	4,998	.19	.20
March [a]			97	5,937	.20	.23
April	130	103	109	6,512	.23	.26
May	2,700	132	718	44,168	1.51	1.74
June	3,000	418	1,238	73,700	2.61	2.91
July	406	110	220	13,500	.46	.53
August	141	89	108	6,650	.23	.27
September	105	76	88	5,232	.18	.20
October	104	94	97	5,994	.20	.23
November	162	96	109	6,512	.23	.26
December [a]			90	5,534	.19	.22
The year	3,000	76	264	184,271	.54	7.27

[a] Jan. 1 to Mar. 15 and Dec. 18 to 31, river frozen; quantities estimated.

NOTE.—The daily discharges were obtained from the discharge measurements by interpolation.

UINTA RIVER AT FORT DUCHESNE, UTAH.

This river, on its emergence from its canyon, spreads out in numerous channels over its flood plain until it reaches a point a short distance above Fort Duchesne, where its waters are collected into one channel. Whiterocks River enters some distance above this point. A number of canals for the use of the Indians divert water between Fort Duchesne and the agency. On the west side are a number of small ditches, which in the aggregate take considerable water; but the amount is difficult to estimate. On the east side are two principal ditches, known as Canal No. 1 and Bench ditch. This station was established September 14, 1899, in connection with the investigation of the water supply for the Uinta Indian Reservation, and is located at the highway bridge at the fort. The permanent rod was established November 8, 1899, and is nailed to the southern end of the east crib of the new bridge. The bench mark is a nail is the southeast crib in the first header above the bottom and is at an elevation of 4,910.13 feet. The elevation of the zero of the rod is 4,907.20 feet.

Discharge measurements of Uinta River at Fort Duchesne, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 3	C. T. Prall	(a)	134
January 9	do		123
January 16	do		126
February 6	do		133
February 13	do		129
February 20	do		125
February 27	do		145
March 7	do	2.70	111
March 12	do	2.68	119
March 20	do	2.66	113
March 26	do	2.70	123
April 5	do	2.65	104
April 9	do	2.60	93
April 16	do	2.54	76
April 23	do	2.65	109
April 30	do	2.57	87
May 7	do	2.72	131
May 14	do	3.90	388
May 21	do	3.42	429
May 28	do	4.33	1,625
June 5	do	4.05	1,125
June 11	do	3.92	928
June 18	do	3.35	407
June 25	do	3.12	281
July 2	do	3.18	312
July 9	do	2.88	186
July 18	Prall and Reed	2.80	138
July 23	H. S. Reed	2.67	93
July 30	do	2.50	56
August 7	do	2.40	40
August 14	do	2.50	59
August 21	do	2.36	32
August 28	do	2.43	43
September 4	do	2.40	37
September 11	do	2.30	24
September 18	do	2.42	37
September 21	do	3.10	304
September 25	do	2.55	69
October 2	do	2.52	65

a Ice.

Discharge measurements of Uinta River at Fort Duchesne, Utah—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
October 8	H. S. Reed	2.55	67
October 22	do	2.55	70
October 30	do	2.58	66
November 5	do	2.61	77
November 12	do	2.80	151
November 19	do	2.70	114
November 26	do	2.62	65
December 3	do	2.60	56
December 9	do	2.81	105
December 19	do	2.90	83
December 26	do		92

Daily gage height, in feet, of Uinta River at Fort Duchesne, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	(a)	(a)	2.60	2.75	2.60	4.30	3.14	2.45	2.47	2.52	2.58	2.60
2			2.60	2.65	2.62	4.05	3.17	2.43	2.45	2.52	2.58	2.60
3			2.53	2.64	2.65	3.90	3.09	2.41	2.42	2.52	2.55	2.60
4			2.48	2.63	2.68	3.95	3.05	2.40	2.41	2.52	2.59	2.53
5			2.53	2.63	2.72	3.98	3.03	2.40	2.39	2.53	2.60	2.60
6			2.60	2.63	2.75	3.95	3.00	2.40	2.37	2.53	2.60	2.70
7			2.85	2.63	2.75	3.93	2.98	2.40	2.35	2.53	2.60	2.75
8			2.85	2.63	2.85	3.93	2.93	2.40	2.35	2.54	2.62	2.80
9			2.83	2.62	2.99	4.03	2.87	2.40	2.35	2.55	2.62	2.80
10			2.80	2.60	3.26	3.85	2.85	2.38	2.35	2.55	2.62	2.80
11			2.74	2.58	3.48	3.74	2.83	2.37	2.35	2.55	2.73	2.80
12			2.68	2.58	3.74	3.73	2.81	2.50	2.37	2.58	2.78	2.80
13			2.70	2.58	3.68	3.70	2.80	2.50	2.38	2.58	2.67	2.62
14			2.68	2.58	3.85	3.68	2.77	2.50	2.38	2.58	2.68	2.57
15			2.66	2.56	3.94	3.58	2.74	2.48	2.38	2.58	2.68	2.53
16			2.68	2.54	4.00	3.48	2.72	2.45	2.40	2.57	2.64	2.48
17			2.68	2.53	4.08	3.42	2.78	2.43	2.40	2.56	2.65	2.48
18			2.68	2.54	3.80	3.38	2.79	2.40	2.40	2.56	2.68	2.66
19			2.65	2.55	3.60	3.29	2.73	2.40	2.43	2.56	2.70	2.80
20			2.65	2.60	3.53	3.25	2.70	2.38	2.45	2.56	2.70	2.80
21			2.65	2.70	3.39	3.24	2.70	2.38	2.98	2.56	2.70	(a)
22			2.65	2.80	3.31	3.20	2.68	2.35	2.58	2.56	2.70	
23			2.65	2.68	3.26	3.17	2.65	2.32	2.52	2.56	2.70	
24			2.68	2.66	3.19	3.11	2.63	2.38	2.52	2.56	2.70	
25			2.70	2.65	3.30	3.10	2.62	2.38	2.52	2.58	2.70	
26			2.70	2.60	3.50	3.10	2.62	2.38	2.52	2.58	2.62	
27			2.70	2.60	4.03	3.10	2.59	2.35	2.52	2.58	2.62	
28			2.72	2.60	4.48	3.10	2.57	2.43	2.52	2.60	2.62	
29			2.65	2.60	4.45	3.11	2.51	2.50	2.52	2.60	2.62	
30			2.65	2.58	4.43	3.12	2.50	2.50	2.52	2.60	2.62	
31			2.70		4.44		2.47	2.49		2.60		

a River frozen.

Rating table for Uinta River at Fort Duchesne, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.3	20	3.2	320	4.1	1,230	5.0	3,064
2.4	40	3.3	370	4.2	1,432	5.1	3,268
2.5	60	3.4	420	4.3	1,636	5.2	3,472
2.6	92	3.5	500	4.4	1,840	5.3	3,676
2.7	126	3.6	580	4.5	2,044	5.4	3,880
2.8	160	3.7	660	4.6	2,248	5.5	4,084
2.9	200	3.8	770	4.7	2,452		
3.0	240	3.9	890	4.8	2,656		
3.1	280	4.0	1,050	4.9	2,860		

Estimated monthly discharge of Uinta River at Fort Duchesne, Utah.

[Drainage area, 672 square miles.]

Month.	Discharge in second-feet.			Run-off.			Rainfall in inches.
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.	
1902.							
January [a]			125	7,686	0.19	0.22	1.7
February [a]			130	7,220	.19	.20	[illegible]
March	180	56	118	7,252	.18	.21	.14
April	160	70	98	5,857	.15	.17	[illegible]
May	2,002	92	662	40,703	.99	1.14	[illegible]
June	1,636	280	622	37,012	.93	1.04	[illegible]
July	308	54	158	9,729	.24	.28	[illegible]
August	60	24	43	2,676	.06	.07	[illegible]
September	232	30	54	3,217	.08	.09	1.4
October	92	66	79	4,852	.12	.14	[illegible]
November	153	60	102	6,052	.15	.17	[illegible]
December [a]			85	5,205	.13	.15	[illegible]
The year	2,002	24	190	137,461	.28	3.88	4.8[illegible]

[a] January 1 to March 1 and December 21 to 31, river frozen; quantities estimated.

NOTE.—Daily discharges from November 26 to December 31 were obtained from the discharge measurements by interpolation.

UINTA RIVER NEAR WHITEROCKS, UTAH.

During the fall of 1899 an investigation of the water supply of the Uinta Indian Reservation was begun by Cyrus C. Babb, and in this connection a number of gaging stations were established. Uinta River emerges from its canyon about 10 miles northwest of the Indian agency at Whiterocks, and at this point a gaging station was established September 16, 1899. The gage rod is a 2 by 4 inch timber, 12 feet long, bolted to two trees on the left bank of the stream. The bench mark is a nail in an aspen tree 125 feet north of the rod, and its elevation is 8.93 feet above gage datum. During flood stages discharge measurements are made by means of a car and cable, but at ordinary stages they are made by wading. The bed of the stream is rocky and strewn with large bowlders, and the station is not altogether satisfactory, on account of the roughness of the channel. During high water the velocity undoubtedly will be great, owing to the rapid fall of the water. A few hundred yards above the station an important tributary comes in from the east. At the present location a second channel has to be measured, but it will never carry a large volume of water. Farther down the stream a number of larger channels are formed, so that it is difficult to obtain a satisfactory station.

Discharge measurements of Uinta River near Whiterocks, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 6	C. T. Prall	0.90	126
January 13	do	.85	144
February 10	do	.90	128
February 17	do	.65	124
February 24	do	.65	123
March 3	do	1.00	160
March 10	do	.75	123
March 17	do	.85	152
March 24	do	.75	126
March 31	do	.90	178
April 7	do	.80	144
April 14	do	.76	129
April 21	do	.92	179
April 28	do	.82	148
May 5	do	.92	179
May 12	do	1.70	538
May 19	do	1.60	507

Discharge measurements of Uinta River near Whiterocks, Utah—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
May 26	C. T. Prall	1.73	536
June 3	do	2.00	790
June 9	do	2.13	929
June 16	do	1.75	622
June 23	do	1.55	431
June 30	do	1.45	379
July 7	do	1.30	303
July 14	C. T. Prall and H. S. Reed	1.20	251
July 21	H. S. Reed	1.10	217
July 28	do	1.10	195
August 4	do	1.05	182
August 11	do	1.05	191
August 19	do	1.00	177
August 25	do	.97	167
September 1	do	1.00	171
September 8	do	.95	160
September 15	do	.93	160
September 22	do	1.00	177
September 29	do	.95	168
October 6	do	.93	161
October 20	do	.93	149
October 27	do	.90	142
November 3	do	.90	139
Do	do	.90	132
November 10	do	.90	137
November 17	do	.93	140
November 24	do	.90	147
December 1	do	1.07	134
December 17	do	1.28	92
December 23	do	.85	109
December 30	do	1.50	6[illegible]

Daily gage height, in feet, of Uinta River near Whiterocks, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1									1.00			1.07
2												
3			1.00			2.00					0.90	
4								1.05				
5					0.92							
6	0.90									0.93		
7				0.80			1.30					
8									.95			
9						2.13						
10		0.90	.75								.90	
11								1.05				
12					1.70							
13	.85											
14				.76			1.20					
15									.93			
16						1.75						
17		.65	.85								.93	1.28
18												
19					1.60			1.00				
20										.93		
21				.92			1.10					
22									1.00			
23						1.55						.85
24		.65	.75								.90	
25								.97				
26					1.73							
27										.90		
28				.82			1.10					
29									.95			
30						1.45						1.50
31			.90									

Estimated monthly discharge of Uinta River near Whiterocks, Utah. [a]

[Drainage area, 218 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	144	123	136	8,360	0.62	0.71
February	143	123	127	7,083	.58	.60
March	178	123	144	8,837	.66	.76
April	185	129	154	9,164	.71	.79
May	1,200	160	555	34,114	2.55	2.94
June	1,000	379	665	39,579	3.05	3.40
July	430	190	262	16,132	1.20	1.38
August	200	167	181	11,144	.83	.96
September	177	160	167	9,923	.77	.86
October	166	140	152	9,364	.70	.81
November	147	125	139	8,269	.64	.71
December	.....	.....	125	7,686	.57	.66
The year	1,200	123	235	169,655	1.07	14.58

[a] Daily discharges were obtained from the discharge measurements by interpolation.

WHITEROCKS RIVER NEAR WHITEROCKS, UTAH.

A gaging station was established in the canyon of this river about 10 miles above the United States Indian agency at Whiterocks on September 15, 1899, by Cyrus C. Babb, in connection with the investigation of a water supply for the Uinta Indian Reservation. The gage rod consists of a 2 by 4 inch by 12 foot timber bolted to the triple trunk of a tree on the left bank of the stream. The bench mark is a nail in a burnt tree 50 feet east of the rod, and is at an elevation of 10.12 feet above gage datum. During flood stages discharge measurements are made from a car and cable 200 feet above the gage rod. At ordinary stages they are made by wading. The bed of this river is rocky, is strewn with large bowlders, and although permanent in character is not altogether satisfactory because of the fact that it is impossible to obtain accurate soundings.

Discharge measurements of Whiterocks River near Whiterocks, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 7	C. T. Prall	0.80	52
January 14	do	.90	48
February 11	do	.70	39
February 18	do	.75	40
February 25	do	.70	47
March 4	do	1.10	44
March 11	do	.70	47
March 18	do	.70	47
April 1	do	.78	56
April 8	do	.78	54
April 15	do	.72	46
April 22	do	.86	66
April 29	do	.88	66
May 6	do	1.12	101
May 13	do	2.10	429
May 20	do	1.75	293
May 27	do	2.75	851
June 4	do	2.20	490
June 10	do	2.00	425
June 17	do	1.70	276
June 24	do	1.40	169
July 1	do	1.40	166
July 8	do	1.23	133
July 15	Prall and Reed	1.05	91
July 22	H. S. Reed	1.03	77
July 29	do	1.00	78
August 5	do	.97	68
August 12	do	1.00	70
August 18	do	.95	64
August 26	do	.90	63
September 2	do	.93	61
September 9	do	.87	49
September 16	do	.90	51
September 23	do	1.00	67
September 30	do	.90	59
October 7	do	.87	56
October 21	do	.85	51
October 28	do	.83	47
November 4	do	.80	46

Discharge measurements of Whiterocks River near Whiterocks, Utah—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
November 11	H. S. Reed	0.95	63
November 18	do	.90	48
November 25	do	.78	38
December 2	do	2.15	41
December 18	do	1.92	52
December 24	do	.85	40
December 31	do	.85	39

Daily gage height, in feet, of Whiterocks River near Whiterocks, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1				0.78			1.40					
2									0.93			2.15
3												
4			1.10			2.20					0.80	
5								0.97				
6					1.12							
7	0.80									0.87		
8				.78			1.23					
9									.87			
10						2.00						
11		0.70	.70								.95	
12								1.00				
13					2.10							
14	.90											
15				.72			1.05					
16									.90			
17						1.70						
18		.75	.70					.95			.90	1.92
19												
20					1.75							
21										.85		
22				.86			1.03					
23									1.00			
24						1.40						.85
25		.70									.78	
26								.90				
27					2.75							
28										.83		
29				.88			1.00					
30									.90			
31												.85

Estimated monthly discharge of Whiterocks River near Whiterocks, Utah.[a]

[Drainage area, 114 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	54	41	48	2,924	0.42	0.48
February	47	39	41	2,297	.36	.37
March	55	44	48	2,955	.42	.48
April	71	46	57	3,416	.50	.56
May	1 100	76	471	28,947	4.13	4.77
June	900	166	348	20,704	3.05	3.40
July	200	77	109	6,684	.96	1.11
August	76	62	67	4,094	.59	.68
September	67	49	57	3,410	.50	.56
October	59	47	53	3,255	.46	.53
November	63	38	48	2,830	.42	.47
December	52	39	44	2,705	.39	.45
The year	1,100	38	116	84,221	1.02	13.86

[a] Daily discharges were obtained from the discharge measurements by interpolation.

ASHLEY CREEK NEAR VERNAL, UTAH.

This stream drains an area directly east of the Uinta Basin. About 7½ miles above the town of Vernal the river appears from its canyon, and within the next few miles a series of canals divert its low-water flow, which is applied to the adjacent lands—Vernal Valley—which are extensively irrigated. A gaging station was established in the canyon of this stream on March 15, 1900, by C. T. Prall. It is located at the ranch of the observer, E. Marett. The gage is a vertical rod, painted white, fastened to the west side of the single pier of the wagon bridge.

The bench mark at this station was originally at the 4-foot mark, being a 20-penny nail driven into the pier at that point, but owing to the settling of the upper stringers of the pier the upper fastenings to the gage rod pulled out and the bench mark has dropped one-tenth of a foot, so that in the fall of 1902 it was opposite the 3.90-foot mark.

The gage readings have not been disturbed as the bottom upon which the lower stringers rests, to which the rod is fastened, is of a very permanent character.

The channel is straight for a distance above and below the bridge and the bed is rocky. At high stages two other channels discharge a portion of the water and these also have to be measured.

The three principal canals diverting water from Ashley Creek below the gaging station are, in order downstream, Upper Ashley canal, Rock Point canal, and Central Ashley canal.

Discharge measurements of Ashley Creek near Vernal, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 14	C. T. Prall	0.60	46.0
July 16	H. S. Reed	1.00	104.0
November 6	do	.60	43.0
December 12	do	.60	40.0

Daily gage height, in feet, of Ashley Creek near Vernal, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	0.65	0.60	0.60	0.55	1.95	2.80	1.23	0.75	0.70	0.70	0.65	0.60
2	.60	.60	.60	.55	2.55	2.45	1.25	.70	.70	.70	.60	.60
3	.60	.60	.60	.55	2.45	2.35	1.20	.70	.70	.70	.60	.60
4	.60	.60	.60	.55	2.30	2.30	1.20	.70	.70	.70	.60	.60
5	.60	.60	.60	.55	2.20	2.30	1.20	.70	.70	.70	.60	.60
6	.60	.60	.60	.58	2.30	2.20	1.15	.70	.70	.70	.60	.60
7	.60	.60	.60	.60	2.10	2.10	1.15	.70	.65	.70	.60	.60
8	.60	.60	.60	.63	2.30	2.05	1.10	.70	.65	.70	.60	.60
9	.60	.60	.60	.65	2.50	2.03	1.10	.70	.65	.70	.60	.60
10	.60	.60	.60	.65	2.50	1.95	1.10	.70	.65	.70	.60	.60
11	.60	.60	.60	.65	2.60	1.95	1.05	.70	.60	.70	.70	.60
12	.60	.60	.60	.63	2.55	1.90	1.05	.73	.60	.70	.70	.60
13	.60	.60	.60	.60	2.60	1.83	1.00	.75	.60	.70	.65	.60
14	.60	.60	.60	.60	3.05	1.73	1.00	.75	.60	.65	.60	.60
15	.60	.60	.60	.60	2.90	1.68	1.00	.70	.60	.65	.60	.60
16	.60	.60	.55	.60	2.95	1.65	1.00	.70	.60	.65	.60	.60
17	.60	.60	.55	.63	2.85	1.60	1.00	.70	.60	.65	.60	.60
18	.60	.60	.55	.75	2.40	1.55	1.00	.70	.60	.65	.60	.60
19	.60	.60	.55	1.25	2.20	1.50	1.00	.70	.60	.65	.60	.60
20	.60	.60	.55	1.30	2.10	1.45	.95	.70	.70	.65	.60	.60
21	.60	.60	.55	1.10	2.00	1.45	.95	.70	.80	.65	.60	.60
22	.60	.60	.55	.98	1.90	1.38	.90	.70	.75	.65	.60	.60
23	.60	.60	.55	.85	1.80	1.33	.90	.70	.70	.65	.60	.60
24	.60	.60	.55	.80	1.80	1.30	.85	.70	.70	.65	.60	.60
25	.60	.60	.55	.80	1.80	1.30	.85	.70	.70	.65	.60	.60
26	.60	.60	.55	.73	2.25	1.25	.80	.70	.70	.65	.60	.60
27	.60	.60	.55	.83	3.15	1.20	.80	.70	.70	.65	.60	.60
28	.60	.60	.55	.95	3.50	1.20	.80	.70	.70	.65	.60	.60
29	.60	.....	.55	1.40	3.25	1.30	.80	.70	.70	.65	.60	.60
30	.60	.....	.55	1.80	2.95	1.30	.80	.70	.70	.65	.60	.60
31	.60	.....	.55	.....	3.00	.....	.75	.70	.....	.65	.....	.60

Rating table for Ashley Creek near Vernal, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	37	1.4	202	2.3	474	3.2	774
.6	45	1.5	230	2.4	506	3.3	810
.7	55	1.6	258	2.5	538	3.4	846
.8	69	1.7	286	2.6	570	3.5	882
.9	85	1.8	315	2.7	602	3.6	918
1.0	106	1.9	346	2.8	636	3.7	954
1.1	128	2.0	378	2.9	670	3.8	990
1.2	152	2.1	410	3.0	704		
1.3	176	2.2	442	3.1	738		

Estimated monthly discharge of Ashley Creek near Vernal, Utah.

[Drainage area, 250 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Rainfall, in inches, at Vernal 7¼ miles south.
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	
1902.							
January	50	45	45	2,777	0.18	0.21	0.21
February	45	45	45	2,498	.18	.19	.51
March	45	40	42	2,608	.17	.20	.86
April	315	40	78	4,665	.31	.35	.72
May	882	315	533	32,765	2.13	2.46	.42
June	636	152	306	18,226	1.22	1.36	.51
July	164	62	108	6,627	.43	.50	.12
August	62	55	56	3,429	.22	.25	.46
September	69	45	52	3,096	.21	.23	.99
October	55	50	52	3,103	.21	.24	.05
November	55	45	46	2,737	.18	.20	1.12
December	45	45	45	2,767	.18	.21	.97
The year	882	40	117	85,298	.47	6.40	6.94

YAMPA RIVER AT CRAIG, COLO.

This station was established by A. L. Fellows May 25, 1901, at the wagon bridge about 1 mile southwest from Craig, Colo., this point being selected as the most suitable station on Yampa River. The gage consists of a vertical 2 by 4 inch timber fastened to the south abutment of the bridge on the downstream side, the rod being marked in feet and tenths vertically. The wagon bridge is marked every 6 feet. The channel is deep at this point, and at low stages the current is sluggish, but measurements give good results, as the channel changes but little. The observer is H. Jones, of Craig, who reads the rod daily.

The following discharge measurements were made during 1902 by A. J. McCune and J. E. Field:

July 7: Gage height, 3.50 feet; discharge, 987 second-feet.
October 15: Gage height, 2.30 feet; discharge, 243 second-feet.

Daily gage height, in feet, of Yampa River at Craig, Colo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.
1902.						
1	2.60	6.10	7.90	3.60	2.10	1.90
2	2.80	6.80	7.10	3.50	2.00	1.90
3	2.80	7.30	6.80	3.30	2.00	1.90
4	2.90	7.50	7.00	3.40	2.00	1.90
5	2.90	7.70	7.10	3.20	1.90	(a)
6	3.00	7.50	6.90	3.30	1.90	.....
7	3.00	7.30	6.90	3.30	1.90	.....
8	3.20	7.00	6.90	3.20	1.90	.....
9	3.30	7.50	7.00	3.10	1.90	.....
10	3.50	7.65	6.70	3.00	1.90	.....
11	3.60	7.85	6.50	2.90	1.90	.....
12	3.60	7.80	6.40	2.80	1.90	.....
13	3.60	7.50	6.20	2.70	1.90	.....
14	3.70	7.60	5.90	2.70	1.90	.....
15	3.80	7.70	5.60	2.60	1.90	.....
16	3.70	7.80	5.30	2.50	1.90	.....
17	4.00	8.00	5.10	2.40	1.90	.....
18	4.40	7.50	4.90	2.40	1.90	.....
19	4.90	7.00	4.70	2.40	1.90	.....
20	5.30	6.60	4.50	2.50	1.90	.....
21	5.40	6.00	4.30	2.60	1.90	.....
22	5.10	5.70	4.10	2.50	1.90	.....
23	5.00	5.40	3.90	2.50	1.90	.....
24	4.80	5.20	3.90	2.40	1.80	.....
25	4.70	5.40	3.70	2.40	1.80	.....
26	4.80	5.30	3.60	2.30	1.80	.....
27	4.90	7.00	3.40	2.30	1.90	.....
28	5.00	7.40	3.30	2.30	1.90	.....
29	5.20	7.10	3.60	2.30	2.00	.....
30	5.70	7.50	3.60	2.20	2.00	.....
31	.....	7.20	.....	2.20	1.90	.....

[a] No observer.

Rating table for Yampa River at Craig, Colo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
1.8	90	3.4	906	5.0	2,985	6.6	5,891
2.0	136	3.6	1,081	5.2	3,320	6.8	6,285
2.2	198	3.8	1,285	5.4	3,664	7.0	6,683
2.4	276	4.0	1,520	5.6	4,016	7.2	7,086
2.6	370	4.2	1,780	5.8	4,376	7.4	7,494
2.8	480	4.4	2,058	6.0	4,744	7.6	7,904
3.0	606	4.6	2,352	6.2	5,120	7.8	8,316
3.2	748	4.8	2,662	6.4	5,502	8.0	8,728

Estimated monthly discharge of Yampa River at Craig, Colo.

[Drainage area, 1,730 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	4,195	370	1,797	106,929	1.04	1.16
May	8,728	3,320	6,722	413,320	3.89	4.48
June	8,522	825	3,969	236,172	2.29	2.55
July	1,081	198	479	29,452	.28	.32
August	165	90	115	7,071	.07	.08

GREEN RIVER AT GREENRIVER, WYO.

The gaging station at Greenriver, Wyo., is at the crossing of the Union Pacific Railroad. It was established May 2, 1895, at the pump house of the Union Pacific Railroad Company. The rod is fastened to a pile near the east end of the bridge. The bench mark consists of a cross on the third step from the bottom on the south end of the east abutment, and is 12.48 feet above gage datum. As the section under the railroad bridge is poor, discharge measurements are made from the iron highway bridge about one-half mile below. The station was temporarily discontinued during the latter part of 1900 and for part of 1901.

During 1902 the following discharge measurements were made by A. J. Parshall:

March 31: Gage height, 0.48 feet; discharge, 307 second-feet.
April 9: Gage height, 0.85 feet; discharge, 696 second-feet
April 18: Gage height, 0.98 feet; discharge, 797 second-feet.
May 3: Gage height, 1.15 feet; discharge, 958 second-feet.
May 28: Gage height, 2.20 feet; discharge, 2,244 second-feet.

Daily gage height, in feet, of Green River, at Greenriver, Wyo.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.								
1	0.50	1.15	4.12	3.05	1.75	1.10	0.55	[illegible]
2	.50	1.15	4.22	3.00	1.70	1.05	.55	.....
3	.50	1.20	4.27	2.95	1.67	1.05	.55	.....
4	.45	1.15	3.90	2.95	1.60	1.05	.55	.....
5	.45	1.10	3.55	2.97	1.55	1.00	.50	.....
6	.53	1.05	3.47	2.97	1.58	1.00	.50	.....
7	.65	1.00	3.55	2.88	1.50	.97	.50	.....
8	.80	1.00	3.67	2.77	1.45	.95	.50	.....
9	.95	1.00	3.77	2.68	1.40	.95	.50	.....
10	1.00	1.03	3.95	2.57	1.35	.90	.50	.....
11	1.00	1.13	4.20	2.48	1.35	.90	.50	.....
12	.95	1.38	4.50	2.32	1.30	.80	.50	.....
13	.90	1.55	4.75	2.23	1.30	.80	.50	.....
14	.99	1.78	4.67	2.12	1.25	.73	.50	.....
15	.95	1.88	4.57	2.10	1.30	.72	.50	.....
16	1.00	2.08	4.48	2.03	1.30	.75	.50	.....
17	.95	2.35	4.25	2.00	1.30	.70	.50	.....
18	.95	2.60	3.95	2.05	1.25	.68	.50	.....
19	1.10	2.77	3.67	2.12	1.25	.65	.50	.....
20	1.25	2.75	3.47	2.15	1.28	.60	.50	.....
21	1.40	2.70	3.33	2.15	1.20	.95	.50	.....
22	1.40	2.55	3.12	2.10	1.20	1.00	.50	.....
23	1.45	2.42	3.07	2.05	1.20	.95	.50	.....
24	1.50	2.33	3.00	2.00	1.80	.75	.50	.....
25	1.48	2.15	3.03	1.95	2.00	.65	.50	.....
26	1.48	2.05	3.13	1.90	2.20	.60	.50	.....
27	1.28	2.08	3.17	1.85	2.20	.60	.45	.....
28	1.20	2.25	3.25	1.85	2.20	.60	.45	.....
29	1.20	2.85	3.25	1.80	1.65	.57	.45	.....
30	1.20	3.60	3.12	1.80	1.10	.55	.45	.....
31	.....	3.98	.....	1.80	1.10	.....	.45	.....

Rating table for Green River at Greenriver, Wyo., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	30	1.2	1,055	2.3	2,430	3.4	5,822
.2	90	1.3	1,165	2.4	2,630	3.5	6,188
.3	160	1.4	1,275	2.5	2,860	3.6	6,554
.4	240	1.5	1,385	2.6	3,130	3.7	6,920
.5	330	1.6	1,495	2.7	3,410	3.8	7,286
.6	430	1.7	1,605	2.8	3,700	3.9	7,652
.7	530	1.8	1,720	2.9	4,030	4.0	8,018
.8	635	1.9	1,845	3.0	4,375	4.5	9,848
.9	740	2.0	1,975	3.1	4,725	5.0	11,678
1.0	845	2.1	2,110	3.2	5,090		
1.1	950	2.2	2,260	3.3	5,456		

Estimated monthly discharge of Green River at Greenriver, Wyo.

[Drainage area, 7,450 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April	1,385	285	844	50,153	0.11	0.12
May	7,925	845	2,262	138,845	.30	.35
June	10,763	4,375	7,104	419,990	.95	1.06
July	4,550	1,720	2,673	164,043	.36	.42
August	2,260	950	1,387	85,130	.19	.22
September	950	380	656	38,937	.09	.10
October	380	285	329	20,206	.04	.05

Miscellaneous measurements in the Colorado River drainage basin.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1902.				*Sec. feet.*
November 19	W. D. Smith	Gila River	Near mouth	25
November 25	do	do	do	836
December 18	do	do	do	2,109
December 24	do	do	do	238
November 14	S. G. Bennett	Imperial Canal	International boundary	374
December 14	W. D. Smith	do	do	494
October 13	J. E. Field	Yampa	Steamboat Springs, Colo	112
October 16	do	Williams Fork	Hamilton, Colo	47
October 11	do	Grand	Near Piney Creek	488
October 13	do	Elk River	Trull, Colo	147
October 14	do	Yampa	Hayden, Colo	235
July 7	A. J. McCune	Williams Fork		136
July 10	do	Snake	Near Dixon	253
October 11	J. E. Field	Rock Creek	Near McCoy's ranch	11
July 13	W. P. Edwards	Lathos Creek	At mouth	15
July 13	do	Taylor River	Clarke's ranch	259
July 13	do	Spring Creek	Near Gunnison, Colo	19
July 14	do	Cebolla	Between Spencer and Dubois	67
July 15	do	Lake Fork	Carr's ranch	171
July 15	do	Pine Creek	Near Gate View	13
July 15	do	Little Blue Creek	At mouth	9
July 15	do	do	Above junction	18
July 15	do	Little Cimarron Creek.	At mouth	16
July 15	do	Cimarron River	At Cimarron, Colo	119
March 21	A. L. Fellows	Mancos River	Mancos	18
July 12	do	do	do	5
July 17	do	Uncompahgre	Fort Crawford, Colo	63

INTERIOR BASIN.

Under this head is comprised the large extent of arid country which includes nearly the whole of Nevada, the northern and western parts of Utah, and small portions of California and Idaho. Having no outlet to the sea, the entire drainage of this vast basin is lost mainly through evaporation from the numerous lakes and sinks in which the waters of the rivers collect.

The largest of the lakes is Great Salt Lake, which receives the waters of that portion of the basin lying in northern Utah and Idaho. Southwestern Utah drains into Sevier Lake. Other important lakes are Humboldt, Pyramid, Winnemucca, Carson, and Walker, all in western Nevada. These lakes receive the basin drainage from Nevada and California. The principal rivers in this section are as follows:

Bear River has its source on the northern slope of the Uinta Mountains in the northeastern part of Utah, and after a circuitous course, in which it leaves Utah and enters Wyoming, reenters Utah, appears again in Wyoming, then in Idaho, and reenters Utah, it finally discharges its waters into Great Salt Lake. Considerable irrigation is practiced on certain portions of the river. Logan River empties into Bear River in Cache Valley, Utah. Blacksmith Fork is a tributary of Bear River from the western slope of the Wasatch Range.

Weber River rises in the high country east of the Wasatch Mountains. Passing through that range, it appears in the plains region in the vicinity of Ogden, where, after receiving the waters of Ogden River, it discharges into Great Salt Lake. There are a number of good reservoir sites on its upper tributaries, some of which have been utilized within the last year.

Provo River rises on the western slope of the Uinta Mountains and after receiving a number of tributaries enters what is known as Heber Valley, where considerable irrigation is practiced. After crossing this valley it passes through the Wasatch Mountains in a picturesque canyon, and finally enters Utah Valley, where its summer flow is completely diverted for irrigation purposes. Its flood waters discharge into Utah Lake.

Sevier River drains a large area in the southwestern part of Utah. It flows northerly until it enters Juab County, then makes a short bend and flows southwest into Sevier Lake. San Pitch River joins Sevier River near Gunnison, Utah.

Humboldt River rises in the extreme northeastern part of Nevada and flows in a general westerly and southerly direction, finally entering Humboldt Lake, whence its waters find their way into the Humboldt and Carson Sink. The general direction of the mountain ranges of this basin is north and south, crossed at nearly right

angles by the main Humboldt River. The tributaries flow in the general direction of the mountain ranges, and drain either to the north or to the south. During low stages the water of the river is almost wholly diverted. For the future development of the country recourse must be had to the construction of storage reservoirs. Of its tributaries, the North Fork enters it west of Peko, Nev., and the South Fork enters it about 10 miles below Elko, Nev.

Pine Creek is a tributary from the south and joins it near Palisade, Nev. Marys River is one of the headwater tributaries of the Humboldt.

Walker River is formed by two branches which have their sources across the Nevada-California boundary, in California. It flows north and then takes a sharp bend to the southeast, emptying into Walker Lake.

Carson River has its source on the slopes of the Sierra Nevada in eastern California, and flows northward into the State of Nevada. The East and West forks unite near Genoa, Nev., in Carson Valley. At Empire, 3 miles east of Carson, after having traversed the Upper Carson Valley, it turns to the northeast and enters a deep canyon, through which it flows for several miles, emerging into a second smaller valley a short distance above the town of Dayton. After leaving this valley it passes through two other shorter canyons and through one rather large valley before entering Lower Carson Valley, or Carson Sink Valley, as it is also known, and discharging its waters into the Carson Sink.

The Truckee has its source on the slopes of the Sierra Nevada in eastern California and flows northward, entering Lake Tahoe, which is at an elevation of 6,225 feet and the largest body of fresh water in the United States at this considerable altitude. The area of the lake is 193 square miles. Its outlet is at Tahoe, Cal., from which point Truckee River has a general northward and eastward course, receiving several important tributaries which contribute to its flow. It drains into Pyramid and Winnemucca lakes, which have no outlets. Donner and Prosser creeks are tributaries of Truckee River. Independence Creek discharges into the Little Truckee, a main branch of Truckee River, entering it at Boca, Cal. They drain areas of 31, 56, and 8.5 square miles, respectively, lying to the northwest of Lake Tahoe, in California.

Susan River has its source in the Sierra Nevada in northeastern California, and flowing eastward discharges into Honey Lake—one of the land-locked lakes of the Great Basin—of which it is the principal feeder. A considerable area of land is irrigated from the waters of the river below the gaging station, and during the last ten or twelve years several projects have been started for irrigating other extensive areas by the storage of its waters both above and below the town of Susanville.

The following is a list of stations in the Interior drainage basin:

Bear River near Collinston, Utah.
Bear River at Battlecreek, near Preston, Idaho.
Blacksmith Fork at Hyrum, Utah.
Logan River near Logan, Utah.
Weber River near Uinta, Utah.
Provo River near Provo, Utah.
Sevier River near Gunnison, Utah.
San Pitch River near Gunnison, Utah.
Humboldt River near Oreana, Nev.
Humboldt River near Golconda, Nev.
Humboldt River at Palisade, Nev.
Pine Creek at Palisade, Nev.
Humboldt River (South Fork) at Mason's ranch, near Elko, Nev.
Humboldt River near Elko, Nev.
Humboldt River (North Fork) near Elburz station, near Halleck, Nev.
Marys River at Bradley's Home ranch, near Deeth, Nev.
Walker River near Wabuska, Nev.
Walker River (East Fork) at Ross ranch, near Yerington, Nev.
Walker River (West Fork) at upper end of Antelope Valley, near Coleville, Cal.
Carson River near Empire, Nev.
Carson River (East Fork) at Rodenbah's ranch, near Gardnerville, Nev.
Carson River (West Fork) at Woodfords, Cal.
Truckee River at Tahoe, Cal.
Truckee River at Vista, near Reno, Nev.
Truckee River near Mystic, at Nevada-California State line.
Independence Creek below Independence Lake, near Overton, Cal.
Prosser Creek below Prosser Creek Ice Company's dam, near Boca, Cal.
Donner Creek near Donner Ice Company's dam, near Truckee, Cal.
Susan River near Susanville, Cal.

BEAR RIVER NEAR COLLINSTON, UTAH.

The gaging station at Collinston was established July 1, 1889, and is located about 4 miles from the railroad station at Collinston, 2 miles east of the town of Fielding, Utah, and below the headworks of the Bear River canal. The gage consists of a vertical iron rod graduated to tenths of a foot. The bench mark is a nail in an oak post 20 feet west of the gage and 20 feet north of the cable, and is at an elevation of 7.35 feet above gage datum. The equipment consists of a cable, a tagged wire, and a boat. The observer is generally the ditch rider of the Bear River Canal Company, who has a house near the station. The banks of the stream are high and the channel is gravelly, with bowlders, the water flowing with moderate velocity. At this point it has a slope of 0.55 foot in 600 feet.

During 1902 the following discharge measurements were made by G. L. Swendsen:

July 16: Gage height, 0.40 foot; discharge, 324 second-feet.
July 20: Gage height, 0.30 foot; discharge, 205 second-feet.
August 13: Gage height, 0.40 foot; discharge, 68 second-feet.
August 26: Gage height, 0.45 foot; discharge, 60 second-feet.
December 30: Gage height, 0.51 foot; discharge, 402 second-feet.

Daily gage height, in feet, of Bear River near Collinston, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.70	1.65	1.85	1.65	2.90	3.50	0.40	−0.10	−0.65	0.80	0.80	0.35
2	1.75	1.60	1.75	1.65	2.90	3.60	.30	− .10	− .55	.80	.80	.35
3	1.80	1.60	1.75	1.70	2.90	3.60	.30	− .10	− .20	.80	.80	.40
4	1.80	1.65	1.75	1.75	2.90	3.45	.40	− .10	− .10	.80	.80	.40
5	1.80	1.60	1.65	1.80	2.80	3.30	.40	− .15	− .15	.80	.80	.45
6	1.80	1.55	1.65	1.90	2.70	3.15	.35	− .20	− .20	.80	.80	.50
7	1.80	1.55	1.65	1.90	2.60	3.00	.35	− .25	− .30	.80	.80	.50
8	1.85	1.60	1.65	2.40	2.60	3.00	.35	− .30	− .20	.80	.80	.55
9	1.85	1.75	1.70	3.00	2.70	3.00	.40	− .35	− .30	.40	.80	.60
10	1.80	1.80	1.80	2.90	2.80	3.10	.40	− .35	− .20	1.00	.90	.60
11	1.80	1.85	1.80	2.75	2.90	3.10	.40	− .40	− .20	.30	1.10	.60
12	1.80	1.85	1.75	2.75	3.00	3.10	.40	− .40	− .10	.90	1.20	.80
13	1.75	1.90	1.75	2.75	3.10	3.10	.35	− .40	− .10	.90	1.30	.70
14	1.70	1.90	1.70	2.75	3.15	3.00	.35	− .40	− .10	.90	1.40	.60
15	1.70	1.70	1.70	2.75	3.15	3.00	.40	− .40	− .10	.90	1.50	.50
16	1.70	1.70	1.65	2.70	3.20	2.90	.45	− .45	− 10	.90	.50	.40
17	1.70	1.70	1.65	2.65	3.25	2.80	.45	− .45	.00	.90	.50	.30
18	1.60	1.80	1.70	2.65	3.30	2.60	.40	− .45	.10	.90	.50	.30
19	1.65	1.80	1.70	2.70	3.30	2.50	.30	− .45	.10	.90	.45	.35
20	1.65	1.70	1.80	2.80	3.30	2.35	.30	− .45	.20	.90	.40	.40
21	1.65	1.70	1.75	3.00	3.30	2.20	.25	− .45	.30	.90	.50	.40
22	1.65	1.65	1.80	3.20	3.20	2.10	.20	− .45	.30	.80	.50	.40
23	1.66	1.65	1.80	3.20	3.20	2.00	.15	− .45	.30	.80	.50	.40
24	1.60	1.65	1.75	3.10	3.10	1.90	.10	− .50	.30	.90	.50	.40
25	1.40	1.65	1.70	3.30	3.10	1.80	.20	− .50	.30	.90	.40	.45
26	1.40	1.70	1.70	3.30	3.10	1.70	.20	− .50	.30	.90	.40	.45
27	1.40	2.00	1.70	3.20	3.20	1.60	.10	− .50	.40	.80	.30	.40
28	1.40	1.95	1.70	3.10	3.25	1.40	.10	− .55	.50	.80	.30	.40
29	1.45	.....	1.70	3.00	3.30	.50	.10	− .55	.60	.80	.35	.40
30	1.50	.....	1.70	2.90	3.35	.50	.00	− .60	.70	.80	.35	.40
31	1.65	.....	1.65	.....	3.45	.....	−.10	− .60	.....	.80	.....	.40

Rating table for Bear River near Collinston, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
−0.1	280	0.7	370	2.0	1,470	3.6	3,340
.0	280	.8	410	2.2	1,670	3.8	3,600
.1	280	.9	460	2.4	1,880	4.0	3,860
.2	285	1.0	520	2.6	2,100	4.2	4,140
.3	290	1.2	690	2.8	2,330	4.4	4,420
.4	300	1.4	870	3.0	2,570	4.6	4,700
.5	310	1.6	1,070	3.2	2,820	4.8	5,000
.6	340	1.8	1,270	3.4	3,080	5.0	5,300

Estimated monthly discharge of Bear River near Collinston, Utah.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	1,320	870	1,139	70,034	0.19	0.22
February	1,470	1,020	1,191	66,145	.20	.22
March	1,320	1,120	1,191	73,232	.20	.23
April	2,950	1,120	2,176	129,481	.36	.40
May	3,145	2,100	2,656	163,311	.44	.51
June	3,340	310	2,138	127,220	.36	.40
July	305	280	292	17,954	.05	.06
August	280	280	280	17,217	.05	.06
September	370	280	289	17,197	.05	.06
October	520	290	427	26,255	.07	.08
November	970	290	420	24,992	.07	.08
December	410	290	312	19,184	.05	.06
The year	3,340	280	1,043	752,222	.17	2.38

BEAR RIVER AT BATTLECREEK, IDAHO.

This station, established October 11, 1889, is about 10 miles north of the Utah-Idaho boundary line. The station is of considerable importance from the fact that its location is near the Utah-Idaho line, and the measurements there will indicate the volume of water that passes from Idaho into Utah. During 1901 a large canal was completed, appropriating the waters of the Bear about 8 miles below Soda Springs in sufficient quantity to irrigate about 35,000 acres of very fine land in that locality. The original gage consisted of a vertical board nailed to a pile. This was carried away June 30, 1899, but was replaced on August 4 by a wire and weight, readings being made on a horizontal scale. The bench mark for the old gage was a nail in the southeast corner of a house near the gage, about 1.5 feet from the ground and 10.95 feet above gage datum. There are two bench marks to which the present gage is referred. The first is a nail in the bridge floor beam close to the gage, and the second is three nails in the east side of the north post which supports the station cable. Both of these bench marks are 11.118 feet above the gage datum. The station is equipped with a cable and car.

Discharge measurements of Bear River at Battlecreek, Idaho.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 13	George L. Swendsen	1.60	407
February 1	do	1.80	606
March 15	do	1.72	610
April 20	do	3.00	1,803
May 30	do	3.15	1,961
June 12	do	3.40	2,231
June 18	do	2.40	924
July 21	do	1.25	355
August 11	do	1.19	290
September 29	do	1.32	385
October 6	do	1.58	412
November 3	do	1.62	455
December 24	do	1.70	524

Daily gage height, in feet, of Bear River at Battlecreek, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.60	1.60	1.70	1.70	2.75	3.10	2.30	1.20	1.80	1.45	1.70	1.60
2	1.60	1.60	1.70	1.70	2.75	3.10	2.25	1.15	1.80	1.48	1.65	1.60
3	1.60	1.60	1.70	1.70	2.75	3.10	1.95	1.25	1.80	1.50	1.65	1.60
4	1.00	1.60	1.70	1.75	2.70	3.10	1.88	1.15	1.80	1.55	1.65	1.60
5	(a)	1.60	1.70	1.85	2.65	3.10	1.85	1.20	1.80	1.55	1.65	1.60
6	(a)	1.60	1.70	2.15	2.58	3.10	1.85	1.25	1.80	1.60	1.65	1.60
7	(a)	1.60	1.70	2.70	2.50	3.10	1.85	1.30	1.80	1.60	1.65	1.60
8	(a)	1.60	1.70	3.20	2.60	3.10	1.85	1.35	1.70	1.60	1.65	1.60
9	(a)	(a)	1.70	3.00	2.63	3.10	1.83	1.40	1.60	1.60	1.65	1.60
10	(a)	(a)	1.70	2.90	2.65	3.10	1.80	1.45	1.50	1.60	1.65	1.60
11	(a)	(a)	1.70	2.90	2.70	3.15	1.68	1.50	1.40	1.60	1.65	1.60
12	1.60	(a)	1.70	3.00	2.75	3.15	1.65	1.55	1.30	1.60	1.70	1.60
13	1.60	(a)	1.70	3.50	2.75	3.15	1.65	1.60	1.20	1.60	1.70	1.60
14	1.60	(a)	1.70	3.50	2.75	3.15	1.65	1.65	1.10	1.60	1.70	1.60
15	1.60	(a)	1.70	2.88	2.75	3.10	1.65	1.70	1.10	1.60	1.70	1.60
16	1.60	1.65	1.70	2.80	2.80	3.50	1.58	1.80	1.10	1.60	1.70	1.60
17	1.60	1.65	1.70	2.80	2.85	3.25	1.50	1.80	1.10	1.60	1.70	1.60
18	1.60	1.70	1.70	2.83	3.05	2.95	1.48	1.90	1.15	1.60	1.65	1.60
19	1.60	1.65	1.70	2.90	2.95	2.88	1.43	1.90	1.20	1.60	1.60	1.60
20	1.60	1.65	1.70	2.85	2.90	2.78	1.40	1.90	1.27	1.60	1.60	1.60
21	1.60	1.65	1.70	2.90	3.00	2.73	1.40	1.90	1.30	1.60	1.60	1.60
22	1.60	1.65	1.70	2.80	3.00	2.68	1.40	1.90	1.30	1.60	1.60	1.60
23	1.60	1.65	1.70	2.95	3.00	2.63	1.40	1.90	1.30	1.60	1.60	1.60
24	1.60	1.65	1.70	2.90	3.20	2.58	1.37	1.90	1.30	1.60	1.60	1.60
25	1.60	1.65	1.70	3.20	3.15	2.53	1.35	1.90	1.30	1.60	1.60	1.60
26	1.60	1.65	1.70	3.10	3.10	2.43	1.35	1.90	1.30	1.68	1.60	1.60
27	1.60	1.65	1.70	3.00	3.10	2.33	1.35	1.90	1.32	1.70	1.60	1.60
28	1.60	1.65	1.70	2.95	3.10	2.13	1.35	1.90	1.35	1.70	1.60	.....
29	1.60	.....	1.70	2.90	3.10	2.08	1.33	1.90	1.32	1.70	1.60	.....
30	1.60	.....	1.70	2.85	3.10	2.13	1.30	1.95	1.40	1.70	1.60	.....
31	1.60	.....	1.70	.....	3.10	.....	1.27	1.80	.....	1.70	.....	.....

[a] Gage lost.

Rating table for Bear River at Battlecreek, Idaho, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.1	302	1.8	570	2.5	1,130	3.2	1,928
1.2	324	1.9	632	2.6	1,230	3.3	2,060
1.3	350	2.0	700	2.7	1,334	3.4	2,196
1.4	382	2.1	776	2.8	1,442	3.5	2,336
1.5	420	2.2	856	2.9	1,556		
1.6	464	2.3	942	3.0	1,676		
1.7	514	2.4	1,034	3.1	1,800		

Estimated monthly discharge of Bear River at Battlecreek, Idaho.

[Drainage area, 4,500 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	464	464	464	28,530	0.10	0.12
February	514	464	480	26,658	.11	.11
March	514	514	514	31,605	.11	.13
April	2,336	514	1,438	85,567	.32	.36
May	1,928	1,130	1,493	91,801	.33	.38
June	2,336	776	1,570	93,421	.35	.39
July	942	337	493	30,313	.11	.13
August	666	313	508	31,236	.11	.12
September	570	302	406	24,159	.09	.10
October	514	399	467	28,715	.10	.12
November	514	464	485	28,859	.11	.12
December	464	464	464	28,530	.10	.12
The year	2,336	302	732	529,394	.16	2.21

BLACKSMITH FORK AT HYRUM, UTAH.

Six irrigation canals and one large power canal are supplied by this river, and during the irrigation season the entire supply is utilized. The present gaging station was established July 19, 1900, by George L. Swendsen. It is near the tollgate at the mouth of the canyon. Daily readings are made on a vertical gage. The bench mark, a line of red paint on the top of a short cedar post near the north post of the tollgate, is 8.29 feet above gage datum.

Discharge measurements of Blacksmith Fork at Hyrum, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 27	George L. Swendsen	2.80	112
February 24	do	2.90	114
March 17	do	2.92	113
April 29	do	3.05	129
May 19	do	3.28	176
June 23	do	3.05	130
July 7	do	2.99	130
August 4	do	2.90	115
September 16	do	2.78	103
October 13	do	2.85	119
November 24	do	2.80	108
December 21	do	2.78	102

Daily gage height, in feet, of Blacksmith Fork at Hyrum, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	.....	2.80	2.90	3.05	3.00	3.30	2.80	2.90	2.80	2.85	2.90	2.90
2	.....	2.80	2.90	3.05	3.00	3.30	2.80	2.90	2.80	2.85	2.90	2.90
3	.....	2.92	2.90	3.05	3.00	3.30	2.80	2.90	2.80	2.85	2.85	2.90
4	.....	2.92	2.90	3.05	3.00	3.30	2.80	2.90	2.80	2.90	2.85	2.90
5	2.92	2.92	2.90	3.05	3.00	3.30	2.80	2.85	2.80	2.90	2.85	2.90
6	2.92	2.92	2.90	3.05	3.05	3.30	2.80	2.85	2.80	2.90	2.85	2.90
7	2.80	2.80	2.90	3.05	3.05	3.30	2.80	2.80	2.80	2.90	2.85	2.90
8	2.80	2.80	2.90	3.05	3.05	3.30	2.80	2.80	2.80	2.90	2.90	2.90
9	2.80	2.80	2.90	3.05	3.05	3.30	2.80	2.80	2.80	2.95	2.90	2.90
10	2.80	2.80	2.90	3.05	3.05	3.30	2.80	2.80	2.80	2.95	2.90	2.90
11	2.80	2.80	2.90	3.05	3.05	3.30	2.80	2.80	2.80	2.95	2.90	2.90
12	2.80	2.80	2.90	3.05	3.05	2.90	2.80	2.80	2.80	2.95	2.90	2.90
13	2.80	2.90	2.90	3.05	3.05	2.90	2.80	2.80	2.80	2.95	2.90	2.90
14	2.80	2.90	2.90	3.05	3.00	2.90	2.80	2.80	2.80	2.95	2.90	2.90
15	2.80	2.90	2.90	3.05	3.00	3.20	2.80	2.80	2.80	2.90	2.95	2.90
16	2.80	2.90	2.90	3.05	3.00	3.20	2.80	2.80	2.80	2.95	2.95	2.90
17	2.80	2.90	2.90	2.90	2.90	3.10	2.80	2.80	2.85	2.90	2.95	2.90
18	2.80	2.90	2.80	2.90	2.90	3.10	2.80	2.80	2.85	2.90	2.95	2.90
19	2.80	2.90	2.90	2.90	2.90	3.10	2.80	2.80	2.85	2.90	2.90	2.90
20	2.80	2.90	2.90	2.90	2.90	3.00	2.80	2.80	2.85	2.90	2.90	2.90
21	2.90	2.90	2.90	2.90	2.90	3.00	2.80	2.80	2.85	2.90	2.90	2.90
22	2.80	2.90	2.90	2.90	2.90	3.00	2.80	2.80	2.85	2.91	2.90	2.90
23	2.80	2.90	2.80	2.90	2.90	3.00	2.80	2.80	2.85	2.90	2.90	2.90
24	2.80	2.90	2.90	2.90	3.00	2.90	2.80	2.80	2.85	2.90	2.90	2.90
25	2.80	2.90	2.90	3.00	3.00	2.90	2.80	2.80	2.85	2.95	2.85	2.90
26	2.80	2.90	2.90	3.00	3.00	2.90	2.80	2.80	2.85	2.95	2.85	2.90
27	2.80	2.90	2.90	3.00	3.00	2.80	2.90	2.80	2.85	2.95	2.85	2.90
28	2.80	2.90	2.90	3.00	3.00	2.80	2.90	2.80	2.85	2.95	2.85	2.90
29	2.80	.....	2.90	3.00	3.00	2.80	2.90	2.80	2.85	2.90	2.85	2.90
30	2.80	.....	2.90	3.00	3.00	2.80	2.90	2.80	2.85	2.90	2.90	2.90
31	2.80	.....	2.90	.....	3.00	.....	2.90	2.80	.....	2.90	.....	2.90

Rating table for Blacksmith Fork at Hyrum, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.60	100	2.95	116	3.30	192	3.65	374
2.65	102	3.00	120	3.35	216	3.70	401
2.70	104	3.05	124	3.40	241	3.75	429
2.75	106	3.10	128	3.45	267	3.80	457
2.80	108	3.15	135	3.50	293	3.85	485
2.85	110	3.20	147	3.55	320	3.90	514
2.90	112	3.25	169	3.60	347		

Estimated monthly discharge of Blacksmith Fork at Hyrum, Utah.

[Drainage area, 286 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	112	108	109	6,702	0.38	0.44
February	112	108	111	6,165	.39	.42
March	112	108	112	6,887	.39	.45
April	124	112	120	7,140	.42	.47
May	124	112	119	7,317	.42	.48
June	192	108	146	8,688	.51	.57
July	112	108	109	6,702	.38	.44
August	112	108	109	6,702	.38	.44
September	110	108	109	6,486	.38	.42
October	116	110	113	6,948	.40	.46
November	116	110	112	6,664	.39	.44
December	112	112	112	6,887	.39	.45
The year	192	108	115	83,288	.40	5.48

LOGAN RIVER NEAR LOGAN, UTAH.

The station on Logan River was established June 1, 1896, and is located in the river canyon about 2 miles east of Logan, Utah. One gage is a vertical iron post, set firmly in the middle of the river's bed and graduated to feet and tenths. A second gage rod is a wooden post driven into the ground near the north bank of the river. The bench mark for both rods is a stone 35 feet northeast of the end of the cable on the north side of the river, and is at an elevation of 14.01 feet above gage datum. It is marked by a cross chiseled on the rock and

by the letters "B. M." in red paint. The equipment consists of a cable and car. Owing to a washout regular daily gage records were not taken during 1902.

Discharge measurements of Logan River near Logan, Utah.

Date.	Hydrographer.	Gage height.	Dicharge.
1902.		*Feet.*	*Second-feet.*
January 27	G. L. Swendsen	1.45	103
February 22	do	1.60	124
March 3	do	1.60	107
April 17	do	1.70	153
April 26	do	1.80	163
May 17	do	3.50	588
June 13	do	4.37	1,056
June 27	do	3.60	598
July 5	do	2.90	284
August 12	do	2.82	198
September 16	do	2.80	191
October 13	do	2.72	178
November 24	do	2.65	171
December 23	do	2.67	165

WEBER RIVER NEAR UINTA, UTAH.

The gaging station on Weber River, established in October, 1899, is located in the canyon 5 miles east of Uinta, on the Union Pacific Railroad, immediately above the narrows known as Devils Gate. The gage is vertical, and is supported from above by a projecting timber placed out of reach of high water. The bench mark consists of a spike driven into the first telegraph pole in the canyon above the gage, and is at an elevation of 17.44 feet above gage datum. The equipment consists of a cable, car, and tagged wire.

Discharge measurements of Weber River near Uinta, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 20	G. L. Swendsen	1.48	113
February 10	do	1.30	121
April 12	do	1.52	166
May 12	do	1.75	339
September 22	do	1.22	79
October 20	do	1.40	162
December 28	do	1.35	112

PROVO RIVER NEAR PROVO, UTAH.

The gaging station on Provo River, established July 27, 1889, is located in the canyon, about 6 miles from Provo and above the head of most of the irrigation canals of Utah Valley. The diversion works of the company which develop power at the mouth of Provo Canyon for electric transmission to the mines west of Provo, are located about 5 miles above the station. The gage is inclined and fastened to stakes set in the ground. The bench mark is a stone firmly bedded in the bank near the wagon road, about 100 feet southwest of the gage. It is marked "B. M." in black paint, and is 6.95 feet above gage datum. The channel is straight for some distance above and below the station. The bed of the river is gravel and not liable to change. The equipment consists of a cable, car, and tagged wire.

Discharge measurements of Provo River near Provo, Utah.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 26	G. L. Swendsen	4.00	204
March 10	do	4.35	230
April 14	do	4.50	395
May 5	do	4.60	414
July 26	do	4.10	202
September 20	do	4.00	172
November 17	do	3.95	165
December 27	do	4.00	178

SEVIER RIVER NEAR GUNNISON, UTAH.

The station, established by Caleb Tanner on June 29, 1900, is at the bridge which crosses the stream 4 miles west of the town of Gunnison. The gage, which is vertical, is nailed to one of the bridge piles. The bench mark consists of a post at the southeast corner of the bridge, marked, in pencil, "U. S. G. S. gage B. M.," and its elevation is 13.23 feet above gage datum. During 1902 the following measurements were made by Caleb Tanner:

May 18: Gage height, 0.88 foot; discharge, 41 second-feet.
August 15: Gage height, 0.62 foot; discharge, 19 second-feet.

Daily gage height, in feet, of Sevier River, near Gunnison, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.00	(a)	1.50	1.82	0.42	0.50	0.80	0.52	0.60	0.55	0.40	0.95
2	2.05	1.82	1.50	1.32	.42	.55	.80	.52	.60	.50	.35	.95
3	2.10	1.82	1.52	1.30	.42	.50	.60	.52	.62	.50	.35	1.05
4	2.10	2.00	1.45	1.30	.42	.50	.60	.57	.60	.50	.35	1.05
5	2.10	2.02	1.40	1.30	.42	.50	.60	.57	.60	.47	.35	1.00
6	2.10	2.27	1.40	1.32	.45	.42	.67	.67	.60	.47	.35	1.00
7	2.05	2.30	1.40	1.32	.55	.42	.60	.67	.60	.45	.35	1.50
8	2.10	2.42	1.40	1.32	.55	.42	.60	.62	.62	.45	.35	1.70
9	2.10	2.42	1.10	1.32	.55	.42	.50	.62	.62	.45	.35	1.70
10	2.15	2.37	1.10	1.35	.60	.40	.50	.62	.62	.45	.35	1.55
11	2.10	2.37	1.10	1.35	.70	.40	.50	.62	.62	.45	.35	1.60
12	2.10	2.45	1.10	1.35	.80	.40	.50	.62	.62	.45	.35	1.60
13	2.10	2.40	1.02	1.25	.80	.40	.50	.62	.62	.45	.35	1.55
14	2.10	2.40	1.02	1.20	.97	.40	.50	.62	.62	.50	.35	1.60
15	2.10	2.37	1.02	1.20	.97	.42	.50	.60	.62	.50	.35	1.65
16	2.05	2.00	1.05	1.15	1.10	.50	.50	.60	.62	.50	.37	1.55
17	2.05	2.00	1.20	1.15	1.00	.65	.52	.60	.60	.50	.35	1.60
18	2.02	1.97	1.15	1.12	.90	.65	.52	.60	.60	.50	.35	1.60
19	2.00	1.90	1.12	1.15	.80	.70	.60	.60	.60	.50	.35	1.70
20	2.00	1.85	1.25	1.22	.70	.70	.57	.60	.60	.50	.35	1.70
21	2.00	1.82	1.22	1.20	.65	.70	.57	.60	.60	.47	.50	1.65
22	2.02	1.77	1.22	1.20	.55	.67	.55	.60	.60	.47	.50	1.65
23	1.92	1.70	1.22	1.15	.50	.62	.52	.60	.60	.47	.50	1.70
24	1.92	1.62	1.12	1.10	.50	.62	.52	.60	.60	.45	.90	1.70
25	1.92	1.62	1.22	1.15	.47	.62	.50	.60	.57	.45	.90	1.65
26	(a)	1.60	1.25	1.05	.50	.60	.50	.60	.57	.45	.75	(a)
27	(a)	1.60	1.25	.70	.50	.60	.50	.60	.60	.45	.80	(a)
28	(a)	1.55	1.55	.47	.42	.60	.50	.60	.60	.45	.85	(a)
29	(a)	.....	1.55	.42	.52	.80	.50	.60	.57	.45	.97	(a)
30	(a)	.....	1.52	.42	.50	.80	.50	.60	.57	.45	.97	(a)
31	(a)	.....	1.45	.....	.50	.....	.52	.....	.....	.45	.....	(a)

[a] Frozen.

Rating table for Sevier River near Gunnison, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	6	1.1	59	1.8	129	2.5	199
.5	11	1.2	69	1.9	139	2.6	209
.6	17	1.3	79	2.0	149	2.7	219
.7	25	1.4	89	2.1	159	2.8	229
.8	33	1.5	99	2.2	169	2.9	239
.9	41	1.6	109	2.3	179		
1.0	49	1.7	119	2.4	189		

Estimated monthly discharge at Sevier River near Gunnison, Utah.

[Drainage area, 3,986 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	164	139	151	9,285	0.038	0.044
February	194	104	149	8,275	.037	.038
March	104	51	76	4,673	.019	.022
April	84	7	65	3,868	.017	.019
May	59	7	20	1,230	.005	.006
June	33	6	15	893	.004	.004
July	33	11	14	861	.004	.005
August	23	12	17	1,045	.004	.005
September	19	15	17	1,012	.004	.004
October	14	8	9	553	.002	.002
November	46	5	14	833	.004	.004
December	119	45	100	6,149	.025	.029
The year	194	5	54	38,677	.014	.182

Investigations in relation to the amount of seepage in the Sevier River Basin between Panguitch and the Sevier Bridge between Scipio and Juab.

WATER ENTERING THE DIFFERENT VALLEYS.

Date.	Locality.	Source.	Quantity.
1902.			*Second-feet.*
August 9	Panguitch Valley	Sevier River	46.2
August 10–11	Junction Valley	do	27.0
		East Fork of Sevier River	16.2
		City Creek	4.0
	Total		47.2
August 11	Between Junction and Marysvale.	Sevier River	10.7
		Tenmile Creek	1.0
		Cottonwood Creek	3.5
		Cottonwood Wash Spring	2.0
	Total		17.2

Investigations in relation to the amount of seepage in the Sevier River Basin between Panguitch and the Sevier Bridge between Scipio and Juab—Cont'd.

WATER ENTERING THE DIFFERENT VALLEYS—Continued.

Date.	Locality.	Source.	Quantity.
1902.			*Second-feet.*
August 11–13	Marysvale Valley	Sevier River	38.0
		Bullion Creek	12.5
		Beaver Creek	2.5
	Total		53.0
August 13–14	Sevier Valley to Rocky Ford.	Sevier River	47.5
		Clear Creek	7.3
		Monroe Creek	3.9
		Thompsons Creek	.2
		Redbutte and Cottonwood creeks.	.3
		Water Canyon Creek	.3
		Spring Creek	5.3
		Cove Creek	9.5
		Cedar Ridge Creek	.5
	Total		74.8
August 14–15	Rocky Ford to Redmond Ford.	Sevier River	1.5
		Rocky Ford canal	35.0
		Lost Creek	.7
		Salina Creek	7.8
	Total		45.0
August 15–16	Redmond Ford to Westview Bridge.	Sevier River	15.5
		Westview canal	4.2
		Willow Creek	.5
		Sanpitch River	15.2
	Total		35.4
Do	Westview Bridge to McArty's Ford.	Sevier River	18.7
		Dover canal	10.7
		Warm Creek	2.7
	Total		32.1
August 16	McArty's Ford to Sevier Bridge.	Sevier River	22.0

Investigations in relation to the amount of seepage in the Sevier River Basin between Panguitch and the Sevier Bridge between Scipio and Juab—Cont'd.

AMOUNT OF WATER DIVERTED FOR IRRIGATION IN THE DIFFERENT VALLEYS

Date.	Locality.	Canal or ditch.	Quantity.
1902.			*Second-feet.*
August 9	Panguitch Valley	East Panguitch Irrigation Co. canal.	11.9
		Long Canal Co. canal	16.6
		East Bench Co. canal	3.8
		Panguitch Creek	13.6
		Little Creek	.3
		McEwan ditch	6.0
		Houston ditch	5.0
		Tibb's ditch	.3
		Orton's ditch	1.9
		Peterson ditch	2.2
		Walley ditch	4.3
		Vaetor ditch	Dry.
		Kessler ditch	2.1
		Johnson ditch	Dry.
	Total		68.0
August 10–11	Junction Valley	Miscellaneous canals	38.7
		Junction Canal Co. upper ditch	5.0
		Junction Canal Co. middle ditch	4.4
		Junction Canal Co. lower ditch	4.5
		Private ditch	1.2
	Total		53.8
August 11	Between Junction and Marysvale.	Not given	6.5
August 11–13	Marysvale Valley	do	15.0
August 13–14	Sevier Valley to Rocky Ford.	Clear Creek irrigation canal	1.38
		Joseph City irrigation canal	3.85
		Wells irrigation canal	2.38
		Isaacson irrigation canal	3.03
		Monroe irrigation canal	7.25
		Elsinore irrigation canal	2.75
		Brooklin irrigation canal	5.50
		Richfield irrigation canal	17.50
		Anabella irrigation canal	11.18
		Candor irrigation canal	.50
		Vermilion irrigation canal	9.04
	Total		64.96

Investigations in relation to the amount of seepage in the Sevier River Basin between Panguitch and the Sevier Bridge between Scipio and Juab—Cont'd.

AMOUNT OF WATER DIVERTED FOR IRRIGATION IN THE DIFFERENT VALLEYS—Continued.

Date.	Locality.	Canal or ditch.	Quantity.
1902.			*Second-feet.*
August 14–15	Rocky Ford to Redmond Ford.	Not given	43.5
August 15–16	Redmond Ford to Westview Bridge.	Robbins canal	8.14
		Westview canal	4.20
		Other canals	15.70
	Total		28.04
Do	Westview Bridge to McArty's Ford.	Not given	13.4
August 16	McArty's Ford to Sevier Bridge.		None.

AMOUNT OF WATER LEAVING THE DIFFERENT VALLEYS.

Date.	Locality.	Name of river or canal.	Quantity second-feet.
1902.			
August 10	Panguitch Valley	Sevier River	30.7
August 11	Junction Valley	do	10.7
Do	Between Junction and Marysvale.	do	38.0
August 13	Marysvale Valley	do	47.5
August 14	Sevier Valley to Rocky Ford.	do	1.5
		Rocky Ford and Willow Bend canal.	35.0
	Total		36.5
August 15	Rocky Ford to Redmond Ford.	Sevier River	15.5
		West View canal	4.2
	Total		19.7
Do	Redmond Ford to Westview Bridge.	Sevier River	18.7
		Dover canal	10.7
	Total		29.4
Do	Westview Bridge to McArty's Ford.	Sevier River	22.0
August 16	McArty's Ford to Sevier Bridge.	do	18.5
Do	Panguitch to Sevier Bridge.	do	18.5

Investigations in relation to the amount of seepage in the Sevier River Basin between Panguitch and the Sevier Bridge between Scipio and Juab—Cont'd.

RÉSUMÉ.

Date.	Locality.	Quantity of water.				Seepage.
		Entering valley.	Used for irrigation.	Leaving valley.	Leaving valley and used for irrigation.	
1902.		*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
August 8–10	Panguitch Valley	46.2	68.0	30.7	98.7	52.5
August 10–11	Junction Valley	47.2	53.8	10.7	64.5	17.3
August 11	Between Junction and Marysvale.	17.2	6.5	38.0	44.5	27.3
August 11–13	Marysvale Valley	53.0	15.0	47.5	62.5	9.5
August 13–14	Sevier Valley to Rocky Ford.	74.8	64.36	36.5	100.86	26.06
August 14–15	Rocky Ford to Redmond Ford.	45.0	43.5	19.7	63.2	18.2
August 15–16	Redmond Ford to Westview Bridge.	35.4	28.04	29.4	57.44	22.04
Do	Westview Bridge to McArty's Ford.	32.1	13.4	22.0	35.40	3.3
August 16	McArty's Ford to Sevier Bridge.	22.0	0.0	18.5	18.5	3.5
August 8–16	Panguitch to Sevier Bridge.	142.1	292.6	18.5	311.1	169.0

SAN PITCH RIVER NEAR GUNNISON, UTAH.

The station, established by Caleb Tanner on June 30, 1900, is 4 miles northeast of the town of Gunnison, at the ranch of the observer, J. P. Jensen. The gage consists of a vertical post driven firmly into the bed of the stream and strongly braced. The bench mark is the top of a cedar post 1 foot in diameter, set firmly in the ground, 40 feet west of the gage rod. Its elevation is 5.96 feet above gage datum. During 1902 the following measurements were made by Caleb Tanner:

May 17: Gage height, 2.28 feet; discharge, 81 second-feet.
August 16: Gage height, 1.79 feet; discharge, 15 second-feet.

Daily gage height, in feet, of San Pitch River near Gunnison, Utah.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.74	1.74	1.74	1.80	2.40	2.30	2.00	1.70	1.75	1.75	1.77	1.70
2	1.74	1.74	1.74	1.80	2.50	2.30	2.08	1.70	1.75	1.75	1.77	1.70
3	1.74	1.74	1.76	1.80	2.60	2.20	2.00	1.70	1.75	1.75	1.70	1.80
4	1.74	1.74	1.76	1.80	2.50	2.20	2.00	1.70	1.75	1.75	1.70	1.80
5	1.74	1.74	1.76	1.80	2.70	2.20	2.00	1.70	1.75	1.75	1.70	1.80
6	1.74	1.76	1.76	1.76	2.70	2.20	2.00	1.80	1.75	1.75	1.70	1.75
7	1.76	1.76	1.76	1.70	2.70	2.20	2.00	1.80	1.75	1.75	1.70	1.75
8	1.76	1.76	1.76	1.90	2.65	2.20	2.00	1.80	1.75	1.75	1.70	1.70
9	1.76	1.76	1.76	1.87	2.60	2.10	2.00	1.80	1.75	1.75	1.70	1.70
10	1.76	1.76	1.76	1.85	2.65	2.10	2.00	1.80	1.75	1.75	1.70	1.70
11	1.76	1.76	1.76	1.80	2.70	2.20	2.00	1.80	1.75	1.75	1.70	1.70
12	1.76	1.76	1.76	1.90	2.75	2.20	2.00	1.75	1.75	1.75	1.70	1.70
13	1.76	1.76	1.76	1.90	2.70	2.10	2.00	1.80	1.75	1.75	1.70	1.70
14	1.76	1.76	1.76	1.90	2.80	2.10	2.00	1.80	1.75	1.75	1.70	1.70
15	1.76	1.76	1.76	1.90	2.40	2.10	2.00	1.80	1.75	1.75	1.70	1.65
16	1.76	1.76	1.76	1.90	2.40	2.15	2.00	1.80	1.75	1.75	1.70	1.65
17	1.76	1.76	1.76	1.97	2.30	2.15	2.00	1.70	1.75	1.75	1.70	1.65
18	1.76	1.76	1.76	2.00	2.80	2.15	2.10	1.70	1.75	1.75	1.70	1.65
19	1.76	1.76	1.76	2.20	2.30	2.10	2.10	1.70	1.75	1.75	1.70	1.70
20	1.76	1.76	1.76	2.10	2.20	2.10	2.10	1.80	1.75	1.75	1.70	1.70
21	1.76	1.76	1.76	2.20	2.20	2.00	2.00	1.80	1.85	1.75	1.70	1.70
22	1.76	1.74	1.76	2.10	2.10	2.20	2.00	1.80	1.85	1,75	1.70	1.70
23	1.76	1.74	1.76	2.00	2.10	2.10	2.00	1.80	1.80	1.75	1.70	1.70
24	1.76	1.74	1.76	2.20	2.20	2.12	1.90	1.80	1.75	1.75	1.70	1.70
25	1.76	1.74	1.76	2.20	2.20	2.00	1.90	1.80	1.75	1.75	1.70	1.70
26	1.76	1.74	1.76	2.30	2.30	2.00	1.80	1.80	1.75	1.77	1.70	1.70
27	1.76	1.74	1.76	2.30	2.30	2.00	1.76	1.80	1.75	1.77	1.70	1.70
28	1.76	1 74	1.76	2.30	2.40	2.10	1.70	1.80	1.75	1.77	1.70	1.70
29	1.76	.....	1.76	2.30	2.30	2.10	1.70	1.80	1.75	1.77	1.70	1.70
30	1.76	.....	1.76	2.40	2.30	2.10	1.70	1.80	1.75	1.77	1.70	1.70
31	1.76	.....	1.76	.....	2.30	.....	1.70	1.75	.....	1.77	.....	1.70

Rating table for San Pitch River near Gunnison, Utah, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.70	10	1.92	27	2.14	57	2.36	89
1.72	11	1.94	30	2.16	59	2.38	92
1.74	12	1.96	32	2.18	62	2.40	95
1.76	13	1.98	34	2.20	65	2.42	98
1.78	14	2.00	37	2.22	68	2.44	101
1.80	15	2.02	40	2.24	71	2.46	104
1.82	17	2.04	43	2.26	74	2.48	107
1.84	19	2.06	45	2.28	77	2.50	110
1.86	21	2.08	48	2.30	80		
1.88	23	2.10	51	2.32	83		
1.90	25	2.12	54	2.34	86		

Estimated monthly discharge of San Pitch River near Gunnison, Utah.

[Drainage area, 836 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	13	12	13	799	0.02	0.02
February	13	12	13	722	.02	.02
March	13	12	13	799	.02	.02
April	95	10	40	2,380	.05	.06
May	155	51	101	6,210	.12	.14
June	80	37	54	3,213	.06	.07
July	51	10	33	2,029	.04	.05
August	15	10	14	861	.02	.02
September	21	13	14	833	.02	.02
October	15	13	13	799	.02	.02
November	15	10	10	595	.01	.01
December	15	7	10	615	.01	.01
The year	155	7	27	19,855	.03	.46

HUMBOLDT RIVER NEAR OREANA, NEV.

On the lower reaches of this river measurements have been made for a number of years near Oreana, and the results show the amount of water available for storage at the possible reservoir sites in the vicinity of Humboldt station, and also for the six canal systems now in operation below Oreana. The station established by L. H. Taylor, January 27, 1896, was located at the old Oreana highway bridge, about 12 miles northeast of Lovelocks, Nev. The bridge abutment to which the gage was fastened was undermined and fell May 26, 1897. A temporary gage was used until September 8, 1897, when a new inclined one was placed on the left bank of the river about a mile and a half above the sight of the old gage and opposite the C. P. Railroad section house.

This gage was washed out and a new vertical gage, in two parts, was placed November 29, 1902, by E. C. Murphy. The gage was spiked to piles at the site of the old dam, the zero of the old and new gages coinciding. The bench mark is four nails driven into piles to which the upper part of the gage is fastened. Its elevation is 5 feet above the zero of gage. The channel here is straight for about 500 feet above the gage and for about 150 feet below. The station is provided with a cable and car. The river banks are high and not liable to overflow. The bed of the stream is sandy and shifting. The observer is G. A. Sapp.

During 1902 the following discharge measurements were made by E. C. Murphy and D. W. Hays:

July 23: Gage height, 1.75 feet; discharge, 251 second-feet.
October 17: Gage height, 0.17 foot; discharge, 22 second-feet.

Daily gage height, in feet, of Humboldt River near Oreana, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
1902.												
1	0.70	0.80	0.90	1.10	1.00	1.00	2.20	1.30	0.20	0.50	0.40	0.50
2	.70	.90	.80	1.10	1.00	1.30	2.00	1.20	.10	.50	.40	.40
3	.70	.90	.80	1.20	1.00	1.50	1.90	1.30	.10	.60	.40	.40
4	.80	1.00	.90	1.20	.90	1.70	1.90	1.30	.10	.60	.40	.50
5	.80	1.00	1.00	1.20	.70	1.80	2.10	1.20	.20	.60	.30	.60
6	.80	1.20	1.00	1.20	.60	1.60	2.20	1.20	.30	.60	.30	.40
7	.90	1.30	.90	1.20	.40	1.60	2.40	1.10	.30	.40	.30	(a)
8	.90	1.30	1.00	1.20	.40	1.50	2.60	1.10	.30	.30	.30	(a)
9	1.00	1.60	1.00	1.10	.50	1.40	2.70	1.00	.40	.30	(a)	(a)
10	1.00	1.40	.90	1.10	.60	1.10	2.50	.90	.40	.30	(a)	(a)
11	1.10	1.40	1.00	1.00	.60	.80	2.30	1.00	.60	.20	(a)	(a)
12	1.10	1.20	1.00	1.00	.50	.60	2.20	1.00	.60	.30	(a)	(a)
13	1.30	1.20	1.00	1.00	.60	.60	2.20	.90	.60	.30	(a)	(a)
14	1.20	1.00	1.00	1.00	.70	.50	2.10	.80	.60	.40	(a)	.20
15	1.00	.90	1.00	1.20	.70	.50	2.10	.80	.60	.40	(a)	.20
16	1.00	.90	1.00	1.20	.70	.50	2.00	.70	.40	.30	.20	.20
17	.90	.80	1.00	1.20	.60	.60	2.00	.70	.40	.30	.20	.10
18	.90	.80	1.00	1.30	.60	.80	1.90	.70	.40	.20	.30	.10
19	.90	.80	1.10	1.30	.50	.80	1.80	.80	.50	.20	.30	.20
20	1.00	.70	1.10	1.30	.50	1.00	1.70	.70	.50	.20	.20	.20
21	1.00	.70	1.10	1.20	.30	1.30	1.90	.70	.50	.30	.20	.20
22	1.20	.60	1.10	1.10	.30	1.30	1.80	.60	.30	.30	.20	.20
23	1.20	.70	1.10	1.10	.10	1.50	1.80	.60	.30	.20	.20	.10
24	1.30	.70	1.10	1.00	.10	1.60	1.80	.60	.40	.10	.20	.10
25	1.40	.70	1.20	1.00	.20	1.70	1.70	.60	.40	.10	.30	.20
26	1.40	.80	1.20	1.00	.30	1.60	1.70	.50	.30	.10	.30	.30
27	1.10	.90	1.20	1.00	.50	1.60	1.60	.50	.30	.20	.50	.30
28	1.00	.90	1.10	1.00	.60	1.70	1.40	.50	.40	.30	.50	.30
29	1.00	.....	1.10	1.00	.70	1.70	1.40	.40	.40	.30	.50	.30
30	.90	.....	1.10	.90	.90	2.00	1.40	.40	.50	.40	.50	.30
31	.80	.....	1.10	.....	1.00	.....	1.30	.40	.....	.40	.....	.20

Rating table for Humboldt River near Oreana, Nev.[a]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	19	0.8	69	1.5	168	2.2	333
.2	24	.9	80	1.6	187	2.3	364
.3	29	1.0	92	1.7	207	2.4	397
.4	35	1.1	105	1.8	229	2.5	432
.5	42	1.2	119	1.9	252	2.6	470
.6	50	1.3	134	2.0	277	2.7	511
.7	59	1.4	150	2.1	304	.....	.....

[a] Only two gagings were made at this station during 1902 and this table is but approximate, being constructed from these and the discharge curve for the year 1901.

Estimated monthly discharge of Humboldt River near Oreana, Nev.

[Drainage area, 13,800 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	150	59	94	5,780	0.007	0.008
February	187	50	91	5,054	.007	.007
March	119	69	96	5,903	.007	.008
April	134	80	107	6,367	.008	.009
May	92	19	52	3,197	.004	.005
June	277	42	137	8,152	.010	.011
July	511	134	276	16,970	.020	.023
August	134	35	75	4,612	.005	.006
September	50	19	35	2,083	.003	.003
October	50	19	32	1,968	.002	.002
November	42	24	30	1,785	.002	.002
December	50	19	28	1,722	.002	.002
The year	511	19	88	63,593	.006	.086

HUMBOLDT RIVER NEAR GOLCONDA, NEV.

The gaging station at Golconda is located near the great northern bend of Humboldt River and below the central valley. It is about 12 miles above the mouth of Little Humboldt River. The station was established by L. H. Taylor October 24, 1894, and has been maintained continuously since that time. It is located 1¼ miles north of the town. The new inclined gage, installed November 28, 1902, by E. C. Murphy, is fastened to the left bank by 4 by 4 inch stakes. The zeros of the old and new gages are at the same elevation. The bench mark is a 4 by 4 inch timber driven 4 feet north of the cable post on the left bank, at an elevation of 10.75 feet above the zero of the gage. Measurements are made from a cable and suspended car. The banks are moderately high, but liable to overflow at extreme high water. The bed of the stream is of gravel and sand and is somewhat shifting.

During 1902 the following discharge measurements were made by E. C. Murphy and D. W. Hays:

July 24: Gage height, 2.40 feet; discharge, 218 second-feet.
October 16: Gage height, —0.16 foot; discharge, 1.2 second-feet.

Daily gage height, in feet, of Humboldt River near Golconda, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.10	1.10	1.70	2.20	2.80	3.15	4.30	1.60	0.60	0.40	−0.10	+0.10
2	1.05	1.10	1.70	2.30	2.75	3.15	4.20	1.50	.50	.30	− .10	.00
3	1.00	1.15	1.70	2.20	2.70	3.20	4.25	1.40	.40	.20	− .15	.00
4	1.00	1.15	1.80	2.25	2.70	3.25	4.20	1.35	.35	.20	− .15	.00
5	1.05	1.20	1.90	2.30	2.75	3.30	4.15	1.30	.40	.15	− .20	− .10
6	1.00	1.20	2.00	2.30	2.75	3.30	4.10	1.35	.40	.10	− .15	− .10
7	1.05	1.15	2.00	2.30	2.80	3.35	4.00	1.40	.50	.05	− .10	− .10
8	1.10	1.10	1.90	2.35	2.90	3.35	3.90	1.50	.40	.00	− .10	.00
9	1.20	1.10	2.00	2.35	2.90	3.40	3.80	1.40	.30	− .05	− .10	.00
10	1.30	1.10	2.00	2.30	3.00	3.40	3.70	1.30	.20	− .10	− .15	.10
11	1.40	1.15	2.10	2.35	3.10	3.45	3.60	1.20	.10	− .20	− .10	.10
12	1.50	1.20	2.05	2.40	3.15	3.50	3.50	1.25	.20	− .10	− .10	.15
13	1.60	1.20	2.00	2.50	3.20	3.55	3.30	1.20	.30	− .10	− .10	.15
14	1.60	1.30	2.10	2.60	3.20	3.60	3.20	1.10	.25	.00	− .10	.15
15	1.60	1.40	1.90	2.70	3.15	4.00	3.10	1.00	.10	− .10	.00	.10
16	1.50	1.50	1.90	2.70	3.15	4.10	2.95	.90	.00	− .20	.00	.10
17	1.50	1.50	1.90	2.60	3.10	4.15	2.75	.80	.00	− .10	.10	.00
18	1.40	1.60	1.90	2.65	3.20	4.20	2.70	.70	.00	− .20	.10	.10
19	1.40	1.60	2.00	2.70	3.20	4.25	2.70	.60	.00	− .20	.15	.10
20	1.30	1.65	2.00	2.50	3.15	4.25	2.60	.50	.90	− .20	.15	.10
21	1.30	1.60	2.10	2.60	3.15	4.30	2.65	.40	.90	− .15	.10	.10
22	1.40	1.60	2.10	2.60	3.20	4.30	2.50	.30	.80	− .15	.10	.20
23	1.30	1.50	2.10	2.70	3.20	4.35	2.50	.10	.70	− .10	.10	.30
24	1.20	1.60	2.10	2.70	3.15	4.30	2.40	.20	.60	− .10	.10	.30
25	1.10	1.65	2.00	2.60	3.20	4.35	2.40	.25	.65	.00	.15	.40
26	1.10	1.60	2.15	2.60	3.15	4.30	2.30	.30	.70	.10	− .10	.40
27	1.15	1.65	2.00	2.70	3.20	4.30	2.20	.35	.75	.15	− .15	.50
28	1.10	1.70	2.10	2.75	3.20	4.35	2.10	.40	.60	.20	− .20	.60
29	1.10	.....	2.15	2.75	3.20	4.30	1.90	.50	.50	.15	− .10	.60
30	1.00	.....	2.10	2.80	3.15	4.30	1.80	.55	.40	.10	− .10	.70
31	1.00	.....	2.15	.....	3.15	.....	1.70	.60	.....	.00	.....	.80

Rating table for Humboldt River near Golconda, Nev., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−0.2	0.8	2.2	139	4.6	584	7.0	1,400
.0	3.0	2.4	162	4.8	635	7.2	1,495
.2	8.0	2.6	188	5.0	688	7.4	1,594
.4	14.0	2.8	217	5.2	743	7.6	1,700
.6	22.0	3.0	248	5.4	802	7.8	1,815
.8	30.0	3.2	283	5.6	865	8.0	1,943
1.0	40.0	3.4	320	5.8	931	8.2	2,088
1.2	52.0	3.6	359	6.0	1,000	8.4	2,256
1.4	66.0	3.8	400	6.2	1,073	8.6	2,451
1.6	82.0	4.0	443	6.4	1,149	8.8	2,675
1.8	99.0	4.2	488	6.6	1,228	9.0	2,935
2.0	118.0	4.4	535	6.8	1,311	9.2	3,235

Estimated monthly discharge of Humboldt River near Golconda, Nev.

[Drainage area, 10,780 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	82	40	56	3,443	0.0052	0.0060
February	90	46	65	3,610	.0060	.0062
March	134	90	117	7,194	.0109	.0126
April	217	139	177	10,532	.0164	.0183
May	288	202	258	15,864	.0239	.0276
June	523	273	413	24,575	.0383	.0427
July	511	90	282	17,339	.0262	.0302
August	82	5	38	2,337	.0035	.0040
September	35	3	16	952	.0015	.0017
October	14	1	4	246	.0004	.0005
November	6	1	3	179	.0003	.0003
December	30	2	8	492	.0007	.0008
The year	523	1	120	86,763	.0111	.1509

HUMBOLDT RIVER AT PALISADE, NEV.

This station was established November 27, 1902, by E. C. Murphy. It is located at Palisade, Nev. The gage is a plain staff graduated to feet and tenths, located about an eighth of a mile downstream from the cable from which the measurements are made. The gage is read daily by J. O. Brooks. The channel is straight for 200 feet above and 300 feet below the station. The banks are both high. The bed of the stream is permanent. The bench mark is a spike and three nails driven in the timber to which the gage is fastened. Its elevation is 7 feet above the zero of the gage.

Daily gage height, in feet, of Humboldt River at Palisade, Nev.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.			1902.		
1		1.35	9		1.55	17		1.50	25		1.5
2		1.35	10		1.55	18		1.50	26		1.5
3		1.30	11		1.55	19		1.45	27	1.35	1.4
4		1.50	12		1.60	20		1.40	28	1.40	1.5
5		1.50	13		1.55	21		1.40	29	1.45	1.5
6		1.55	14		1.50	22		1.45	30	1.35	1.4
7		1.55	15		1.45	23		1.50	31		1.5
8		1.55	16		1.40	24		1.55			

PINE CREEK AT PALISADE, NEV.

This station was established November 27, 1902, by E. C. Murphy. It is located at the railway bridge 1 mile southwest of Palisade, Nev. The gage is a plain staff graduated to feet and tenths, spiked to the right abutment of the railroad bridge. It is read daily by J. O. Brooks. The channel both above and below the station is straight. The banks are high and liable to overflow only at very high water. The bed of the stream is permanent and is composed of gravel and sand. The bench mark is a spike and three nails driven into the timber to which the gage is fastened. Its elevation is 7 feet above the zero of the gage.

A measurement was made October 14, 1902, by E. C. Murphy, which showed a discharge of 7.2 second-feet.

Daily gage height, in feet, of Pine Creek at Palisade, Nev.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.			1902.		
1	.....	1.40	9	.....	1.40	17	.....	1.70	25	.....	1.85
2	.....	1.35	10	.....	1.45	18	.....	1.70	26	.....	1.40
3	.....	1.80	11	.....	1.40	19	.....	1.80	27	.....	1.35
4	.....	1.35	12	.....	1.45	20	.....	1.75	28	1.80	1.85
5	.....	1.40	13	.....	1.40	21	.....	1.50	29	1.45	1.70
6	.....	1.45	14	.....	1.50	22	.....	1.75	30	1.45	1.45
7	.....	1.45	15	.....	1.60	23	.....	1.35	31	.....	1.80
8	.....	1.40	16	.....	1.65	24	.....	1.30			

HUMBOLDT RIVER (SOUTH FORK) AT MASON'S RANCH NEAR ELKO, NEV.

The station, established August 29, 1896, by L. H. Taylor, is located 10 miles southwest of the town of Elko and about 6 miles above the junction of the South Fork with the main stream. The gage is inclined and spiked to posts driven firmly into the right bank. A new inclined gage was placed by E. C. Murphy November 22, 1902. It is at the site of the old one, the 4-foot marks of old and new gages coinciding. The bench mark is a 4 by 4-inch timber driven 4 feet south of the gage. It is 6.29 feet above gage datum. The measurements are made from a cable and suspended car at a point 1 mile above the gage, the latter being placed near the farm of the observer, for his convenience. At the point of measurement the banks are high, and the channel is straight for some distance above and below the station. The bed of the stream is of rock and gravel and quite stable. There is a good site for a reservoir a short distance above the station.

In 1902 the following discharge measurement was made by E. C. Murphy:

October 12: Gage height, 0.50 feet; discharge, 12 second-feet.

Daily gage height, in feet, of Humboldt River (South Fork) at Mason's ranch near Elko, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	0.75	0.75	0.95	1.30	2.60	2.95	3.10	1.30	0.65	0.30	1.00	1.20
2	.75	.80	.95	1.30	2.60	3.00	2.90	1.30	.65	.30	1.00	1.20
3	.75	.80	.95	1.40	2.60	3.00	2.90	1.10	.65	.35	1.00	1.20
4	.75	.90	.95	1.40	2.70	3.50	2.80	1.10	.65	.35	1.00	1.20
5	.70	.90	.95	1.40	2.70	3.50	2.75	1.10	.65	.35	1.10	1.20
6	.70	.95	.95	1.90	2.80	4.10	2.50	1.00	.60	.35	1.10	1.20
7	.70	.95	.95	1.95	2.80	4.40	2.50	1.00	.50	.40	1.10	1.30
8	.70	.95	.95	1.95	2.70	4.50	2.35	1.00	.45	.40	1.10	1.30
9	.70	.90	1.10	2.00	2.90	5.00	2.35	1.00	.30	.40	1.10	1.30
10	.70	.90	1.10	2.00	2.90	5.10	2.20	1.00	.30	.40	1.10	1.30
11	.70	.90	1.10	2.00	3.00	5.20	2.20	1.00	.30	.40	1.10	1.30
12	.70	.90	1.10	2.10	3.00	5.40	2.20	1.00	.30	.50	1.20	1.30
13	.70	.90	1.10	2.20	3.10	5.70	2.30	.90	.35	.50	1.20	1.30
14	.70	.90	1.10	2.20	3.10	5.70	2.25	.90	.25	.55	1.20	1.30
15	.70	.90	1.10	2.35	3.10	5.10	2.25	.90	.25	.55	1.20	1.30
16	.70	.90	1.10	2.35	3.20	5.00	2.10	.90	.20	.60	1.20	1.30
17	.70	.90	1.10	2.35	3.30	4.60	2.10	.80	.20	.65	1.20	1.30
18	.70	.90	1.15	2.50	3.10	4.50	2.00	.80	.15	.65	1.20	1.30
19	.70	.90	1.15	2.60	3.10	4.50	2.00	.80	.10	.70	1.20	1.30
20	.70	.90	1.15	2.80	2.80	4.50	1.90	.70	.10	.70	1.20	1.30
21	.70	.90	1.20	2.80	2.75	4.50	1.90	.70	.20	.70	1.20	1.30
22	.70	.90	1.20	2.80	2.75	4.50	1.80	.70	.20	.70	1.20	1.30
23	.70	.95	1.20	2.80	2.60	4.40	1.75	.70	.20	.75	1.10	1.30
24	.70	.95	1.20	2.75	2.60	4.40	1.75	.70	.25	.75	1.10	1.30
25	.70	.95	1.20	2.75	2.70	4.10	1.75	.70	.25	.80	1.10	1.30
26	.75	.95	1.20	2.75	2.80	3.90	1.75	.70	.25	.90	1.20	1.30
27	.75	.95	1.25	2.70	3.00	3.90	1.50	.70	.25	.90	1.20	1.30
28	.75	.95	1.25	2.70	3.40	3.90	1.50	.70	.25	1.00	1.20	1.30
29	.75	.....	1.25	2.70	3.60	3.40	1.40	.70	.25	1.00	1.20	1.30
30	.75	.....	1.30	2.60	3.90	3.20	1.40	.70	.30	1.00	1.20	1.30
31	.75	.....	1.30	.....	3.90	.....	1.40	.65	.....	1.00	.....	1.30

Rating table for Humboldt River (South Fork), at Mason's ranch, Nevada, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*	*Feet.*	*Sec.-feet.*
0.4	7	2.0	276	3.6	740	5.2	1,230
.6	24	2.2	327	3.8	801	5.4	1,292
.8	47	2.4	382	4.0	862	5.6	1,354
1.0	74	2.6	439	4.2	922	5.8	1,416
1.2	105	2.8	499	4.4	983	6.0	1,478
1.4	141	3.0	559	4.6	1,045		
1.6	182	3.2	619	4.8	1,106		
1.8	227	3.4	679	5.0	1,168		

Estimated monthly discharge of Humboldt River (South Fork) at Mason's ranch, near Elko, Nev.

[Drainage area, 1,150 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	41	35	37	2,275	0.032	0.037
February	67	41	61	3,388	.053	.055
March	122	67	92	5,657	.080	.092
April	499	122	349	20,767	.304	.339
May	831	439	550	33,818	.478	.551
June	1,385	544	959	57,064	.834	.934
July	589	141	313	19,246	.272	.314
August	122	30	59	3,628	.051	.059
September	30	0	7	417	.006	.007
October	74	2	29	1,783	.025	.029
November	105	74	96	5,712	.083	.093
December	122	105	119	7,317	.103	.119
The year	1,385	0	223	161,072	.193	2.629

HUMBOLDT RIVER NEAR ELKO, NEV.

The station at Elko, established June 17, 1895, by L. H. Taylor is located at the highway bridge 1 mile southwest of the town. The gage is inclined, fastened to iron bolts driven into the solid rock, and is placed on the left bank immediately below the bridge. The bench mark is on the southwest corner of the cofferdam surrounding the stone pier of the bridge, 80 feet north of the gage, and is at an elevation of 7.50 feet above gage datum. The right bank is quite low; the left is high and rocky. The bed of the stream is of gravel and sand, with a slight tendency to change during flood stages.

The following discharge measurement was made in 1902 by E. C. Murphy.

October 11: Gage height, 1.80 feet; discharge, 1.1 second-feet.

Daily gage height, in feet, of Humboldt River near Elko, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.										
1	1.85	2.50	3.00	2.86	4.30	3.70	3.50	2.20	1.70	1.70
2	1.85	2.50	3.00	2.87	4.25	3.78	3.53	2.15	1.70	1.70
3	1.85	2.50	2.90	2.88	4.10	4.00	3.45	2.15	1.70	1.70
4	1.85	2.50	2.85	2.90	4.10	4.30	3.40	2.15	1.70	1.70
5	1.87	2.40	2.85	2.90	4.00	4.50	3.35	2.15	1.70	1.70
6	1.87	2.40	2.80	2.90	3.90	4.75	3.45	2.15	1.70	1.70
7	1.87	2.50	2.75	2.95	3.80	4.95	3.65	2.00	1.70	1.70
8	1.87	2.40	2.75	3.00	3.75	4.90	3.55	2.00	1.70	1.70
9	1.87	2.50	2.75	3.20	3.75	4.95	3.45	1.90	1.70	1.70
10	1.87	2.50	2.75	3.25	3.60	5.00	3.30	1.90	1.70	1.70
11	1.87	2.40	2.76	3.35	3.60	5.20	3.20	1.90	1.70	1.70
12	2.50	2.40	2.77	3.40	3.65	5.25	3.20	2.00	1.70	1.70
13	2.50	2.50	2.78	3.40	3.75	5.35	3.15	1.90	1.70	1.70
14	2.50	2.50	2.79	3.35	3.80	5.50	3.00	1.90	1.70	(a)
15	2.50	2.60	2.80	3.30	3.85	5.70	2.95	1.90	1.70	.....
16	2.50	2.50	2.80	3.25	3.90	5.65	2.90	1.90	1.70	.....
17	2.50	2.50	2.80	3.28	3.95	5.65	2.85	1.80	1.70	.....
18	2.50	2.50	2.75	3.10	4.00	5.60	2.75	1.80	1.70	.....
19	2.50	2.50	2.80	3.10	4.10	5.65	2.73	1.80	1.70	.....
20	2.50	2.50	2.85	3.20	4.20	5.70	2.75	1.80	1.70	.....
21	2.60	2.60	2.90	3.35	4.25	5.75	2.70	1.75	1.70	.....
22	2.50	2.60	2.90	3.40	4.30	5.60	2.65	1.75	1.70	.....
23	2.40	2.50	2.80	3.50	4.40	5.00	2.60	1.70	1.70	.....
24	2.50	2.60	2.85	4.00	4.30	4.65	2.50	1.70	1.70	.....
25	2.50	2.70	2.90	4.10	4.30	4.20	2.45	1.70	1.70	.....
26	2.50	2.80	3.00	4.40	4.30	4.00	2.43	1.70	1.70	.....
27	2.50	2.90	2.95	4.80	4.25	3.90	2.40	1.70	1.70	.....
28	2.40	3.00	2.90	4.70	4.25	3.75	2.35	1.70	1.70	.....
29	2.40	.....	2.87	4.65	3.60	3.65	2.35	1.70	1.70	.....
30	2.30	.....	2.85	4.60	3.60	3.55	2.30	1.70	1.70	.....
31	2.40	.....	2.85	.....	3.60	.....	2.25	1.70	.....	.....

[a] Discontinued on account of dam backing water up.

Rating table for Humboldt River near Elko, Nev., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	0.5	3.0	190	4.8	743	6.6	1,550
1.7	1.0	3.2	240	5.0	822	6.8	1,655
1.8	7.0	3.4	292	5.2	903	7.0	1,763
1.9	14.0	3.6	346	5.4	988	7.2	1,873
2.0	22.0	3.8	402	5.6	1,076	7.4	1,986
2.2	43.0	4.0	461	5.8	1,166	7.6	2,101
2.4	70.0	4.2	525	6.0	1,257	7.8	2,218
2.6	104.0	4.4	594	6.2	1,352	8.0	2,339
2.8	144.0	4.6	667	6.4	1,449		

Estimated monthly discharge of Humboldt River near Elko, Nev.

[Drainage area, 2,840 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	104	10	57	3,505	0.0197	0.023
February	190	70	96	5,332	.0338	.035
March	190	134	153	9,408	.0539	.062
April	743	155	322	19,160	.1134	.126
May	594	346	460	28,284	.1620	.187
June	1,143	332	767	45,640	.2701	.301
July	360	50	187	11,498	.0658	.076
August	43	1	14	861	.0049	.006
September	1	1	1	60	.0004	.0004
October 1 to 14	1	1	1	28	.0004	.0002

HUMBOLDT RIVER (NORTH FORK) NEAR HALLECK, NEV.

This station was established October 10, 1902, by E. C. Murphy. It is located about 2 miles west of the Southern Pacific Railroad station at Elburz. The nearest post-office is Halleck, Nev. The gage is an inclined 4 by 4 inch timber graduated to read direct to feet and tenths. It is read daily by the observer, Joe Dolce. The measurements are taken from a car and cable. The channel is straight both above and below the station. The current is swift. Both banks are high. The left bank overflows at very high water. The bed of the stream is permanent and composed of gravel and silt. The bench mark is a 4 by 4 inch timber driven into the ground about 20 feet upstream from the cable. Its elevation is 6.99 feet above the zero of the gage.

Daily gage height, in feet, of the Humboldt River (North Fork) near Halleck, Nev.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1		2.20	2.40	12	2.00	2.30	2.50	23	2.10	2.20	2.60
2		2.10	2.50	13	2.00	2.20	2.60	24	2.20	2.20	2.60
3		2.10	2.50	14	2.00	2.20	2.50	25	2.20	2.10	2.50
4		2.20	2.40	15	2.00	2.30	2.60	26	2.20	2.10	2.60
5		2.30	2.50	16	2.00	2.20	2.60	27	2.20	2.30	2.60
6		2.20	2.40	17	2.00	2.30	2.55	28	2.10	2.40	2.60
7		2.20	2.50	18	2.10	2.30	2.60	29	2.20	2.40	2.70
8		2.30	2.60	19	2.10	2.30	2.50	30	2.10	2.40	2.70
9		2.20	2.50	20	2.10	2.30	2.50	31	2.10		2.70
10	1.90	2.20	2.60	21	2.10	2.30	2.40				
11	1.90	2.30	2.60	22	2.20	2.30	2.50				

MARYS RIVER AT BRADLEY'S HOME RANCH, NEAR DEETH, NEV.

This station is located on Bradley's ranch at the wagon bridge about 20 miles upstream from the mouth or from Deeth, Nev. The gage is a vertical staff graduated to feet and tenths, and is spiked to the pier of the bridge. It is read twice daily by George Murry. The channel is straight both above and below the station. The banks are high and the bed of the stream is composed of silt and clay. The bench mark is a 4 by 4 inch timber set on the left bank 35 feet from the gage. Its elevation is 9.28 feet above the zero of the gage.

A measurement October 10, 1902, by E. C. Murphy showed no discharge.

Daily gage height, in feet, of Marys River near Deeth, Nev.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.			1902.		
1		2.30	9		2.40	17		2.45	25	2.40	2.40
2		2.35	10		2.40	18		2.40	26	2.50	2.45
3		2.45	11		2.40	19		2.55	27	2.30	2.40
4		2.40	12		2.40	20		2.45	28	2.25	2.40
5		2.30	13		2.40	21		2.45	29	2.35	2.50
6		2.40	14		2.40	22		2.50	30	2.40	2.40
7		2.40	15		2.30	23		2.45	31		2.40
8		2.40	16		2.45	24	2.45	2.30			

WALKER RIVER NEAR WABUSKA, NEV.

This station was established July 22, 1902, by L. H. Taylor. It was equipped December 12, 1902, by E. C. Murphy. It is located about 2 miles east of Wabuska, Nev. The gage is a vertical staff graduated to feet and tenths and located about 50 feet upstream from the cable, from which measurements are made. The gage is read twice daily by W. H. Mitchell. The channel is straight both above and below the station. The banks are high. The bed of the stream is sandy and shifting. The bench mark is four nails driven in the northwest corner of the pump platform 35 feet east of the gage. The elevation of the bench mark is 6.94 feet above the zero of the gage.

During 1902 the following discharge measurements were made by E. C. Murphy and L. H. Taylor:

July 22: Gage height, 1.00 foot; discharge, 47 second-feet.
October 7: Gage height, 0.48 foot; discharge, 0.71 second-foot.

Daily gage height, in feet, of Walker River near Wabuska, Nev.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						
1	.....	0.60	0.20	0.20	0.60	1.30
2	.....	.55	.20	.20	.60	1.30
3	.....	.50	.20	.20	.60	1.30
4	.....	.50	.20	.25	.55	1.35
5	.....	.45	.20	.25	.55	1.40
6	.....	.40	.20	.25	.55	1.40
7	.....	.40	.20	.30	.60	1.50
8	.....	.40	.20	.30	.65	1.70
9	.....	.40	.20	.30	.65	1.70
10	.....	.40	.20	.30	.70	1.70
11	.....	.40	.15	.30	.70	1.75
12	.....	.40	.15	.30	.80	1.75
13	.....	.40	.15	.30	.90	1.75
14	.....	.40	.15	.30	1.00	1.80
15	.....	.40	.15	.30	1.00	1.90
16	.....	.40	.15	.30	1.00	1.90
17	.....	.35	.15	.30	1.00	1.85
18	.....	.35	.15	.30	1.05	1.85
19	.....	.30	.15	.30	1.15	1.80
20	.....	.30	.20	.30	1.30	1.80
21	.....	.30	.20	.30	1.40	1.75
22	1.00	.30	.20	.30	1.40	1.75
23	.85	.30	.20	.30	1.40	1.75
24	.80	.30	.15	.30	1.40	1.70
25	.75	.30	.15	.30	1.40	1.70
26	.70	.25	.15	.35	1.40	1.65
27	.60	.25	.20	.35	1.40	1.65
28	.60	.25	.20	.35	1.40	1.60
29	.60	.25	.20	.40	1.35	1.55
30	.60	.25	.20	.45	1.30	1.45
31	.60	.25	.....	.60	.....	1.40

WALKER RIVER (EAST FORK) AT ROSS RANCH, NEAR YERINGTON, NEV.

This station was established October 6, 1902, by E. C. Murphy. It is located about 10 miles southeast of Yerington, Nev., at Ross ranch. The gage is a 4 by 4 vertical timber graduated to feet and tenths. It is read daily by I. A. Strosnider, the ranch owner, who lives about 200 yards away. Measurements are made from a cable. The channel is straight both above and below the station. The banks are low and liable to overflow at high water. The bed of the stream is sand and clay and is liable to shift. The bench mark is three nails driven in the stump of a tree 6 inches in diameter and 15 feet east of the gage. Its elevation is 5.85 feet above the zero of the gage.

The following discharge measurement was made in 1902 by E. C. Murphy:

October 6: Gage height, 1.20 feet; discharge, 55 second-feet.

Daily gage height, in feet, of Walker River (East Fork) at Ross ranch, near Yerington, Nev.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	1.70	1.85	12	1.50	1.80	1.80	23	1.60	1.80	1.80
2	.....	1.70	1.90	13	1.50	1.80	1.80	24	1.60	1.80	1.80
3	.....	1.70	1.90	14	1.50	1.80	1.80	25	1.70	1.80	1.80
4	.....	1.70	2.00	15	1.60	1.80	1.80	26	1.70	1.80	1.80
5	.....	1.70	2.00	16	1.60	1.80	1.80	27	1.70	1.80	1.80
6	1.30	1.80	2.10	17	1.60	1.80	1.80	28	1.70	1.80	1.80
7	1.50	1.80	2.10	18	1.60	1.80	1.80	29	1.70	1.80	1.80
8	1.40	1.80	2.10	19	1.60	1.80	1.80	30	1.70	1.80	1.80
9	1.50	1.80	2.10	20	1.60	1.80	1.80	31	1.70	.....	1.80
10	1.50	1.80	2.10	21	1.60	1.80	1.80				
11	1.50	1.80	1.80	22	1.60	1.80	1.80				

WALKER RIVER (WEST FORK) AT UPPER END OF ANTELOPE VALLEY, NEAR COLEVILLE, CAL.

This station was established October 5, 1902, by E. C. Murphy. It is located about 4 miles southwest of Coleville, Cal. The gage is a plain staff graduated to feet and tenths. It is located about one-half mile upstream from the cable from which the measurements are made. The observer is John Trumble. The channel is straight both above and below the station. Both banks are high. The bed of the stream is stony and permanent. The bench mark is a spike driven into the tree to which the gage is fastened. Its elevation is 6 feet above the zero of the gage.

During 1902 the following discharge measurements were made by L. H. Taylor and D. W. Hays:

July 25: Discharge, 331 second-feet.
September 23: Discharge, 32 second-feet.
October 4: Discharge, 70 second-feet.

Daily gage height, in feet, of Walker River (West Fork) near Coleville, Cal.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	1.30	1.30	12	1.00	1.50	1.10	23	1.00	1.30	1.30
2	.....	1.20	1.20	13	1.00	1.20	1.00	24	1.20	1.20	1.10
3	.....	1.20	1.20	14	1.00	1.20	1.30	25	1.20	1.20	1.30
4	.....	1.20	1.30	15	1.00	1.20	1.20	26	1.20	1.30	1.30
5	1.10	1.20	1.40	16	1.00	1.30	1.30	27	1.20	1.30	1.10
6	1.10	1.20	1.30	17	1.00	1.20	1.10	28	1.30	1.10	1.00
7	1.10	1.20	1.30	18	1.00	1.30	1.00	29	1.30	1.30	1.10
8	1.10	1.20	1.30	19	1.00	1.20	1.00	30	1.30	1.30	1.20
9	1.00	1.20	1.30	20	1.00	1.30	1.00	31	1.30	.....	1.20
10	1.00	1.50	1.30	21	1.00	1.40	1.20				
11	1.00	1.50	1.20	22	1.00	1.40	1.20				

CARSON RIVER NEAR EMPIRE, NEV.

On October 21, 1900, a gaging station was established about 2 miles below the town of Empire. The old gage, a temporary one, was vertical, driven into the stream bed, and spiked to a timber set firmly in the left bank. The bench mark was on a stone wall 10 feet from the gage and at an elevation of 7.5 feet above gage datum. The channel is straight, the banks are rather high at the old station, and the bed is composed of cobbles and gravel and is not likely to shift. On February 18, 1901, erosion of a bar in the channel above the gage caused a division of the stream bed into two channels. On March 13, 1901, a permanent gage was placed farther downstream where the banks are more stable. The gage consists of a wooden rod driven vertically into the stream bed and spiked to a cottonwood tree on the left bank. The bench mark is on the top of a large bowlder 10 feet north of the gage, its elevation being 8.38 feet above the datum of the gage.

Discharge measurements of Carson River near Empire, Nev.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 8	C. V. Taylor	3.10	925
April 22	D. W. Hays	2.80	755
May 12	C. V. Taylor	3.70	1,391
July 3	D. W. Hays	2.15	413
July 30	do	.35	23
August 30	L. L. Richards	.45	32

Daily gage height, in feet, of Carson River near Empire, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.60	1.60	2.10	1.90	2.50	3.80	2.30	0.30	0.30	0.20	1.60	1.40
2	1.60	1.60	2.00	1.90	2.50	3.60	2.30	.40	.30	.20	1.50	1.50
3	1.60	1.60	2.20	1.90	2.50	3.30	2.20	.40	.30	.20	1.50	1.50
4	1.70	1.60	2.40	2.00	2.40	3.10	2.10	.40	.20	.20	1.40	1.50
5	1.70	1.60	2.40	2.00	2.50	3.10	2.00	.30	.30	.20	1.30	1.50
6	1.70	1.60	2.70	2.00	2.70	3.10	1.90	.30	.20	.20	1.20	1.50
7	1.70	1.60	2.70	2.30	2.90	3.20	1.80	.20	.20	.20	1.10	1.50
8	1.70	1.60	2.70	2.90	3.10	3.30	1.60	.20	.20	.20	1.00	1.50
9	1.60	1.60	2.80	3.00	3.50	3.50	1.50	.20	.20	.20	1.00	1.60
10	1.60	1.60	2.40	2.70	3.70	3.70	1.40	.10	.20	.20	1.00	1.60
11	1.60	1.60	2.00	2.60	3.70	3.70	1.40	.10	.20	.20	1.00	1.60
12	1.60	1.60	1.90	2.40	3.70	3.80	1.40	.10	.20	.30	1.10	1.50
13	1.50	1.80	1.90	2.40	3.70	3.80	1.50	.20	.20	.30	1.10	1.50
14	1.50	1.70	1.90	2.50	3.70	3.60	1.40	.30	.20	.40	1.20	1.50
15	1.50	1.70	1.90	2.60	3.40	3.50	1.20	.30	.10	.40	1.20	1.50
16	1.60	1.70	1.90	2.70	3.30	3.40	1.10	.30	.10	.50	1.20	1.50
17	1.60	1.70	1.90	2.80	3.30	3.20	1.10	.30	.20	.50	1.20	1.50
18	1.60	1.70	2.00	3.00	3.10	3.10	1.00	.30	.10	.60	1.20	1.50
19	1.60	1.70	2.00	3.10	3.30	3.00	1.00	.30	.20	.60	1.40	1.50
20	1.60	1.70	1.90	3.30	3.10	3.00	.90	.30	.20	.60	1.40	1.50
21	1.50	1.70	1.90	3.30	2.90	3.00	.70	.30	.20	.60	1.40	1.50
22	1.50	1.70	1.90	2.80	2.70	3.00	.60	.30	.10	.70	1.40	1.50
23	1.50	1.70	1.90	2.60	2.70	2.90	.50	.30	.10	.70	1.40	1.50
24	1.50	1.70	1.90	2.50	2.70	2.70	.40	.30	.20	.80	1.40	1.50
25	1.50	1.70	1.80	2.50	2.90	2.60	.40	.30	.20	.90	1.40	1.50
26	1.30	1.70	1.80	2.40	3.20	2.60	.40	.30	.20	1.00	1.40	1.50
27	1.30	2.50	1.80	2.30	3.50	2.60	.40	.20	.20	1.10	1.40	1.50
28	1.20	2.30	1.80	2.30	3.70	2.40	.40	.20	.20	1.20	1.40	1.50
29	1.30	------	1.80	2.30	3.90	2.30	.40	.30	.20	1.40	1.40	1.50
30	1.40	------	1.80	2.30	4.00	2.30	.30	.30	.20	1.40	1.40	1.50
31	1.50	------	1.80	------	3.90	------	.30	.30	------	1.50	------	1.40

Rating table for Carson River near Empire, Nev., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	10	1.1	116	2.1	416	3.1	938
.2	15	1.2	137	2.2	457	3.2	1,008
.3	20	1.3	160	2.3	500	3.3	1,082
.4	25	1.4	185	2.4	545	3.4	1,160
.5	32	1.5	212	2.5	592	3.5	1,242
.6	41	1.6	241	2.6	642	3.6	1,328
.7	52	1.7	272	2.7	695	3.7	1,418
.8	65	1.8	305	2.8	751	3.8	1,512
.9	80	1.9	340	2.9	810	3.9	1,610
1.0	97	2.0	377	3.0	872	4.0	1,712

Estimated monthly discharge of Carson River near Empire, Nev.

[Drainage area, 988 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	272	137	225	13,835	0.228	0.26
February	592	241	279	15,495	.282	.29
March	751	305	411	25,271	.416	.48
April	1,082	340	618	36,774	.626	.70
May	1,712	545	1,041	64,009	1.054	1.22
June	1,512	500	1,002	59,623	1.014	1.13
July	500	20	170	10,453	.172	.20
August	25	10	19	1,168	.019	.02
September	20	10	15	893	.015	.02
October	212	15	54	3,320	.055	.06
November	241	97	160	9,521	.162	.18
December	241	185	213	13,097	.216	.25
The year	1,712	10	351	253,459	.355	4.81

CARSON RIVER (EAST FORK) AT RODENBAH'S RANCH, NEAR GARDNERVILLE, NEV.

The gaging station was established by L. H. Taylor on October 17, 1900, at the place where measurements were made in the years 1890, 1891, and 1892. The old gage was an inclined timber securely fastened to posts set in the right bank of the stream. The old bench mark was on a basalt rock in the edge of the stream, 20 feet from the gage and at an elevation of 6.3 feet above gage datum. The channel at the old station is straight and the banks are high. The stream bed is of cobbles and gravel, and is quite stable.

On August 2, 1901, a loose-rock dam was raised a short distance below the gaging station, which affected the velocity at the latter point. The dam was partly washed out by a freshet on December 4, 1901. A new gage was established on March 10, 1901, a short distance downstream from the original one, which had been destroyed. It consists of a vertical timber driven into the stream bed at the right bank and spiked to a cottonwood tree. A bench mark was also established on a large granite bowlder 20 feet south of the gage under the cable from which the measurements are made. Its elevation is 8.10 feet above the datum of the gage. On October 3, 1902, a new inclined gage was installed by E. C. Murphy at a point on the left bank of the river 600 feet above the cable. This gage has not been read, as the

one placed on March 10, 1901, is still in use. The bench mark is on a rock 2 feet east of the gage. It is 9.945 feet above gage datum.

Discharge measurements of Carson River (East Fork) near Gardnerville, Nev.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 21	D. W. Hays	4.50	514
May 13	C. V. Taylor	5.12	1,138
July 2	D. W. Hays	4.25	486
July 19	do	3.80	192
July 29	do	3.70	139
August 5	C. V. Taylor	3.50	100
September 9	L. L. Richards	3.00	60
October 3	E. C. Murphy	3.20	66

Daily gage height, in feet, of Carson River (East Fork) near Gardnerville, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.30	3.10	3.10	3.80	4.40	4.90	3.80	3.50	3.35	3.05	2.95	3.40
2	3.30	3.10	3.20	3.80	4.40	5.00	4.00	3.60	3.30	2.95	3.00	3.35
3	3.30	3.20	3.10	3.80	4.50	5.20	3.90	3.40	3.10	3.15	2.90	3.3
4	3.30	3.20	3.20	3.80	4.50	5.30	3.90	3.25	3.10	3.10	2.90	3.40
5	3.30	3.20	3.10	3.90	4.60	5.40	3.90	3.40	3.05	3.05	3.00	3.30
6	3.40	3.20	3.10	3.90	4.80	5.50	4.00	3.50	3.00	2.95	3.00	3.3
7	3.30	3.10	3.20	4.90	5.00	5.70	3.80	3.40	3.10	3.10	2.90	3.35
8	3.40	3.20	3.20	4.80	5.20	6.00	3.70	3.60	3.15	3.05	2.90	3.3
9	3.40	3.40	3.40	4.70	5.50	5.40	3.80	3.70	3.05	3.00	3.55	3.3
10	3.30	3.30	3.40	4.40	5.80	5.30	3.90	3.95	3.20	3.10	4.00	3.35
11	3.60	3.20	3.40	4.30	5.20	5.30	3.80	3.75	3.10	3.10	3.75	3.25
12	3.50	3.30	3.40	4.40	5.40	5.40	3.90	3.80	3.05	3.00	3.70	3.3
13	3.50	3.30	3.40	4.40	5.50	5.50	3.80	3.90	3.00	3.10	3.55	3.25
14	3.50	3.30	3.40	4.50	5.50	5.40	3.80	3.85	3.20	2.95	3.50	2.9
15	3.40	3.50	3.50	4.60	5.40	5.50	3.70	3.70	3.15	2.90	3.45	2.9
16	3.50	3.70	3.60	4.60	5.40	5.00	3.80	3.70	3.15	2.95	3.40	2.9
17	3.50	3.60	3.60	4.80	5.50	4.60	3.90	3.75	3.20	3.00	3.25	2.9
18	3.50	3.50	3.60	4.90	4.90	4.70	3.80	3.65	3.00	2.90	3.35	2.9
19	3.40	3.50	3.60	4.70	5.00	4.80	3.80	3.70	2.90	2.90	3.40	2.8
20	3.50	3.50	3.60	4.70	5.20	4.50	3.80	3.70	2.90	2.95	3.35	2.9
21	3.40	3.40	3.70	4.50	5.20	4.60	3.70	3.80	2.85	3.00	3.30	2.7
22	3.50	3.40	3.70	4.30	5.30	4.70	3.70	3.80	2.80	3.20	3.30	2.7
23	3.50	3.30	3.70	4.50	5.60	4.30	3.80	3.65	2.80	3.05	3.40	2.6
24	3.40	3.30	3.60	4.30	5.30	4.20	3.70	3.65	2.75	3.05	3.35	2.6
25	3.10	3.30	3.50	4.60	5.50	4.20	3.60	3.50	2.80	2.95	3.40	2.6
26	2.90	3.30	3.50	4.50	5.40	4.10	3.70	3.50	2.85	2.90	3.40	2.5
27	3.00	3.20	3.60	4.50	5.30	4.00	3.60	3.45	2.90	2.90	3.25	2.6
28	3.10	3.10	3.60	4.30	6.00	4.00	3.50	3.50	3.05	2.85	3.35	2.5
29	3.20	.....	3.70	4.40	5.50	3.90	3.70	3.45	3.00	2.90	3.35	2.5
30	3.20	.....	3.80	4.30	5.40	3.80	3.60	3.45	3.00	3.00	3.40	2.5
31	3.20	.....	3.80	.....	5.20	.....	3.60	3.40	.....	2.95	.....	2.5

Rating table for Carson River (East Fork) near Gardnerville, Nev., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.5	30	3.4	85	4.3	519	5.2	1,200
2.6	34	3.5	98	4.4	598	5.3	1,275
2.7	38	3.6	115	4.5	675	5.4	1,350
2.8	42	3.7	140	4.6	750	5.5	1,425
2.9	46	3.8	180	4.7	825	5.6	1,500
3.0	51	3.9	233	4.8	900	5.7	1,575
3.1	57	4.0	297	4.9	975	5.8	1,650
3.2	65	4.1	368	5.0	1,050	5.9	1,725
3.3	74	4.2	441	5.1	1,125	6.0	1,800

Estimated monthly discharge of Carson River (East Fork) at Rodenbah ranch, near Gardnerville, Nev.

[Drainage area, 381 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth, in inches.
1902.						
January	115	46	81	4,980	0.213	0.25
February	140	57	78	4,332	.205	.21
March	180	57	101	6,210	.265	.31
April	975	180	601	35,762	1.577	1.76
May	1,800	598	1,205	74,093	3.163	3.64
June	1,800	180	955	56,826	2.507	2.80
July	297	98	178	10,945	.467	.54
August	265	70	131	8,055	.344	.40
September	80	40	54	3,213	.142	.16
October	65	44	51	3,136	.134	.15
November	297	46	86	5,117	.226	.25
December	85	28	54	3,320	.142	.16
The year	1,800	28	298	215,989	.782	10.63

CARSON RIVER (WEST FORK) AT WOODFORDS, CAL.

The gaging station, established by L. H. Taylor on October 18, 1900, is about three-fourths of a mile above the post-office at Woodfords. The gage is a vertical timber graduated to feet and tenths. It is read daily by Bernice Merrill, Woodfords, Cal. The channel at the station

is straight, the banks are high and rocky, and the bed is of rock and gravel and not likely to shift. Measurements are made from a car suspended on a steel cable across the stream.

Discharge measurements of Carson River (West Fork) at Woodfords, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
April 22	D. W. Hays	3.65	192
May 13	C. V. Taylor	4.70	422
July 3	D. W. Hays	3.40	158
July 30	do	2.50	47
August 6	C. V. Taylor	2.45	53
September 9	L. L. Richards	2.21	40

Daily gage height, in feet, of Carson River (West Fork) at Woodfords, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.00	3.70	4.40	3.10	3.90	4.60	4.20	2.50	2.30	2.20	2.40	2.5[illegible]
2	2.90	3.90	4.60	3.20	3.90	4.50	3.90	2.40	2.30	2.20	2.40	2.5[illegible]
3	2.90	3.80	4.20	3.40	3.80	4.50	3.80	2.40	2.20	2.20	2.40	2.5[illegible]
4	2.90	3.90	3.90	3.40	3.70	4.40	3.80	2.40	2.20	2.20	2.40	2.5[illegible]
5	2.90	4.00	3.60	3.50	3.70	4.40	3.80	2.40	2.20	2.20	2.30	2.5[illegible]
6	2.80	4.00	3.60	3.80	3.70	4.40	3.60	2.40	2.20	2.20	2.30	2.5[illegible]
7	2.90	4.00	3.50	3.90	3.60	4.40	3.60	2.40	2.20	2.20	2.40	2.5[illegible]
8	3.00	3.50	3.50	3.90	3.60	4.60	3.50	2.40	2.20	2.20	2.30	2.5[illegible]
9	3.00	3.90	3.60	3.80	3.70	4.50	3.40	2.60	2.20	2.20	2.40	2.5[illegible]
10	3.00	3.90	3.60	3.80	3.80	4.50	3.40	2.40	2.20	2.20	2.40	2.5[illegible]
11	2.90	3.80	3.60	3.90	4.00	4.40	3.40	2.30	2.20	2.20	2.50	2.7[illegible]
12	2.90	3.80	3.40	3.90	4.00	4.40	3.20	2.30	2.20	2.20	2.50	2.7[illegible]
13	2.80	3.90	3.50	3.90	4.00	4.40	3.20	2.30	2.30	2.30	2.50	2.6[illegible]
14	2.90	3.80	3.60	3.90	4.10	4.40	3.00	2.40	2.30	2.20	2.60	2.5[illegible]
15	2.90	3.80	3.40	3.80	4.20	4.00	3.00	2.40	2.30	2.30	2.50	2.5[illegible]
16	2.90	3.90	3.30	3.80	4.40	4.20	2.90	2.30	2.30	2.30	2.40	2.6[illegible]
17	3.00	4.00	3.20	3.00	3.80	4.10	2.90	2.30	2.30	2.20	2.40	2.6[illegible]
18	2.90	3.90	3.00	3.50	3.80	4.10	2.90	2.30	2.30	2.20	2.40	2.6[illegible]
19	2.90	3.80	2.80	3.40	3.80	4.10	2.80	2.30	2.30	2.30	2.40	2.6[illegible]
20	3.00	3.90	2.70	3.30	3.90	4.10	2.90	2.30	2.30	2.30	2.40	2.6[illegible]
21	3.20	3.80	2.70	3.30	4.20	4.10	2.90	2.30	2.20	2.30	2.50	2.7[illegible]
22	3.10	3.90	2.80	3.30	4.30	4.20	2.80	2.30	2.20	2.30	2.50	2.7[illegible]
23	3.20	3.90	2.60	3.40	4.40	4.20	2.90	2.30	2.20	2.30	2.50	2.8[illegible]
24	3.20	4.00	2.60	3.40	4.60	4.30	2.90	2.40	2.20	2.30	2.50	2.8[illegible]
25	3.30	4.20	2.60	3.30	4.60	4.20	2.80	2.50	2.20	2.40	2.50	2.8[illegible]
26	3.20	4.20	2.60	3.40	4.80	4.10	2.70	2.40	2.20	2.30	2.60	2.8[illegible]
27	3.40	4.30	2.60	3.30	4.80	4.10	2.70	2.30	2.20	2.20	2.60	2.8[illegible]
28	3.50	4.30	2.60	3.50	4.80	4.20	2.60	2.30	2.20	2.30	2.50	2.8[illegible]
29	3.60	.....	2.60	3.50	4.70	4.30	2.60	2.30	2.20	2.40	2.50	2.6[illegible]
30	3.60	.....	2.60	3.60	4.70	4.30	2.60	2.30	2.20	2.40	2.50	2.6[illegible]
31	3.70	.....	2.80	.....	4.70	.....	2.60	2.30	.....	2.40	.....	2.5[illegible]

Rating table for Carson River (West Fork) at Woodfords, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	2	2.4	42	3.4	147	4.4	342
1.6	6	2.6	57	3.6	178	4.6	393
1.8	12	2.8	75	3.8	213	4.8	448
2.0	20	3.0	96	4.0	252	5.0	508
2.2	30	3.2	120	4.2	295		

Estimated monthly discharge of Carson River (West Fork) at Woodfords, Cal.

[Drainage area, 70 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	195	75	107	6,579	1.53	1.76
February	318	162	238	13,218	3.40	3.54
March	393	57	138	8,485	1.97	2.27
April	232	108	175	10,413	2.50	2.79
May	448	178	287	17,647	4.10	4.73
June	393	252	319	18,982	4.56	5.09
July	295	57	121	7,440	1.73	1.99
August	57	36	40	2,460	.57	.66
September	36	30	32	1,904	.46	.51
October	42	30	34	2,091	.49	.56
November	57	36	46	2,737	.66	.74
December	75	49	58	3,566	.83	.96
The year	448	30	133	95,522	1.90	25.60

TRUCKEE RIVER AT TAHOE, CAL.

Truckee River, the natural outlet of Lake Tahoe, leaves the lake at the city of Tahoe. About 500 feet from the lake there is a timber dam across the river, which has been maintained for more than twenty years, for the purpose of controlling the discharge from the lake. June 17, 1900, a gage was placed in the stream for the purpose of recording the height of the water in the river. The gage is a vertical timber driven into the stream bed at the left bank about 300 feet below the dam, and is spiked to the root of a tree growing on the bank. The bench mark is cut in the side of the tree and is 4 feet above gage datum. The measurements are made from a cable

and suspended car about one-fourth mile below the gage, which was placed as near the city of Tahoe as possible for the convenience of the observer. At the point of measurement the right bank is low and is subject to overflow at very high stages of the stream. The left bank is rather high. The channel is nearly straight for a short distance below the station, and the bed of the river, which is of gravel and coarse sand, is smooth and stable. The purpose of the station is to ascertain the actual overflow from Lake Tahoe with a view to determining its real value as a storage reservoir.

The following measurement was made in 1902 by E. C. Murphy:

October 22: Gage height, 1.67 feet; discharge, 320 second-feet.

Daily gage height, in feet, of Truckee River at Tahoe, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	0.80	0.95	0.40	0.40	0.35	0.80	0.80	1.90	2.00	1.75	1.80	[illegible]
2	.80	.35	.35	.40	.35	.80	.80	1.90	2.00	1.75	1.80	[illegible]
3	.90	.35	.35	.40	.35	.80	.80	1.90	2.00	1.75	1.87	[illegible]
4	.90	.35	.35	.40	.35	.80	.80	1.90	2.00	1.75	1.87	[illegible]
5	.90	.35	.35	.40	.90	.80	.80	1.90	2.00	1.75	1.87	[illegible]
6	.90	.35	.35	.40	.90	.80	.80	1.90	2.00	1.70	1.87	[illegible]
7	.90	.35	.35	.40	.90	.80	.95	1.90	1.80	1.70	1.87	[illegible]
8	.90	.35	.35	.35	.90	.80	.95	1.90	1.80	1.75	1.87	[illegible]
9	.90	.90	.35	.35	.90	.80	.95	1.90	1.80	1.80	1.70	[illegible]
10	.90	.90	.35	.35	.90	.80	.95	1.90	1.80	1.80	1.70	[illegible]
11	.90	.90	.35	.35	.85	.80	.95	1.90	1.80	1.80	1.70	[illegible]
12	.90	.00	.35	.35	.85	.80	.95	1.90	1.80	1.80	1.70	[illegible]
13	.90	.00	.35	.35	.80	.80	.95	1.90	1.80	1.80	1.70	[illegible]
14	.90	.95	.35	.35	.80	.80	1.20	2.10	1.80	1.80	1.70	[illegible]
15	.90	.95	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.70	[illegible]
16	1.00	.95	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.70	[illegible]
17	1.00	.95	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.70	[illegible]
18	1.00	.90	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.70	[illegible]
19	1.00	.90	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.92	[illegible]
20	1.00	.40	.35	.35	.80	.70	1.20	2.10	1.80	1.75	1.92	[illegible]
21	1.00	.40	.35	.35	.80	.75	1.20	2.10	1.75	1.70	1.92	[illegible]
22	1.00	.40	.35	.35	.80	.80	1.20	2.10	1.80	1.70	1.92	[illegible]
23	1.00	.40	.35	.35	.80	.80	1.90	2.10	1.80	1.70	1.92	[illegible]
24	1.00	.40	.35	.35	.80	.80	1.90	2.10	1.80	1.70	1.92	[illegible]
25	.95	.40	.35	.35	.80	.80	1.90	2.00	1.80	1.70	1.92	[illegible]
26	.95	.40	.35	.35	.80	.80	1.90	2.00	1.75	1.70	1.92	[illegible]
27	.95	.40	.30	.35	.80	.80	1.90	2.00	1.75	1.70	1.92	[illegible]
28	.95	.40	.80	.35	.80	.80	1.60	2.00	1.75	1.80	1.92	[illegible]
29	1.05	.....	.80	.35	.80	.80	1.90	2.00	1.75	1.80	1.92	[illegible]
30	.95	.....	.80	.35	.80	.80	1.90	2.00	1.75	1.80	1.93	[illegible]
31	1.05	.....	.40	.....	.80	.....	1.90	2.00	.....	1.80	.....	[illegible]

Rating table for Truckee River at Tahoe, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	25	0.7	85	1.4	225	2.1	445
.1	30	.8	100	1.5	251	2.2	486
.2	36	.9	117	1.6	279	2.3	531
.3	43	1.0	136	1.7	308	2.4	580
.4	51	1.1	156	1.8	339		
.5	61	1.2	178	1.9	372		
.6	72	1.3	201	2.0	407		

Estimated monthly discharge of Truckee River at Tahoe, Cal.

[Drainage area, 519 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	146	100	125	7,686	0.24	0.28
February	126	25	73	4,054	.14	.15
March	100	43	52	3,197	.10	.12
April	51	47	48	2,856	.10	.11
May	117	47	97	5,964	.19	.22
June	100	40	95	5,653	.18	.20
July	372	100	204	12,543	.39	.45
August	445	372	406	24,964	.78	.90
September	407	324	350	20,826	.67	.75
October	339	308	324	19,922	.62	.71
November	407	308	346	20,588	.67	.75
December	407	293	326	20,045	.63	.73
The year	445	25	204	148,298	.39	5.37

TRUCKEE RIVER AT VISTA, NEV.

The station at Vista, Nev., was established August 18, 1899, by L. H. Taylor, and is located 7 miles east of Reno. On November 12, 1902, a new gage was installed by E. C. Murphy. It consists of a vertical 4 by 4 inch timber spiked to a willow tree. It is on the left bank of the river, 150 feet above the new railroad bridge. The zeros of the old and new gages coincide. The bench mark consists of two spikes driven into the root of the willow tree to which the gage is attached.

The elevation of the bench mark is 6.98 feet above the zero of the gage. The cable was moved to a point about a quarter of a mile below the old station. The left bank is low and subject to overflow at extreme high water. The bed is rocky and not subject to change.

The following discharge measurements were made during 1902 by C. V. Taylor:

April 9: Gage height, 5.04 feet; discharge, 1,678 second-feet.
May 9: Gage height, 5.70 feet; discharge, 2,319 second-feet.

Daily gage height, in feet, of Truckee River at Vista, Nev.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.60	2.60	3.40	4.00	4.20	4.60	2.60	2.60	2.80	2.65	3.10	[illegible]
2	2.55	2.70	3.30	4.00	4.00	4.30	2.70	2.50	2.90	2.60	3.10	.....
3	2.50	2.70	3.20	4.45	3.80	4.00	2.60	2.40	3.00	2.70	3.10	.....
4	2.65	2.65	3.20	4.00	3.90	4.00	2.60	2.40	3.10	2.65	3.20	.....
5	2.75	2.65	3.20	4.80	3.90	4.00	2.70	2.40	2.80	2.60	3.10	.....
6	2.75	2.65	3.30	7.00	4.50	4.00	2.60	2.30	2.90	2.60	3.10	.....
7	2.80	2.60	3.30	7.00	5.20	4.20	2.60	2.20	3.10	2.60	3.00	.....
8	2.80	2.60	3.50	5.60	5.70	4.50	2.50	2.20	2.80	2.70	3.00	.....
9	2.75	2.65	3.10	5.00	5.70	4.70	2.50	2.10	2.90	2.70	3.30	.....
10	2.75	2.60	3.05	5.00	5.40	4.80	2.50	2.10	2.70	2.70	3.40	.....
11	2.70	2.60	2.95	5.40	5.60	4.90	2.40	2.10	2.60	2.70	3.50	.....
12	2.60	2.65	3.00	5.00	5.70	4.50	2.40	2.20	2.60	2.80	3.60	.....
13	2.60	2.70	2.90	5.72	5.50	4.40	2.20	2.10	2.70	2.70	3.00	.....
14	2.60	2.90	2.85	5.75	5.30	4.40	2.20	2.40	2.80	2.80	3.70	.....
15	2.60	4.00	2.90	5.71	5.00	4.00	2.30	2.60	2.70	2.80	4.00	.....
16	2.60	4.00	2.80	5.77	4.70	3.90	(a)	2.80	2.60	2.80	3.90	.....
17	2.60	3.60	2.80	5.77	4.80	3.80	.....	2.50	2.70	2.70	3.80	.....
18	2.65	3.20	2.85	5.76	4.70	3.70	.....	2.60	2.60	2.90	3.80	.....
19	2.70	3.25	2.90	5.79	4.60	3.70	.....	2.50	2.60	2.90	3.70	.....
20	2.60	3.25	2.90	5.77	4.20	3.60	.....	2.60	2.70	3.10	3.60	.....
21	2.60	3.20	2.85	5.77	4.10	3.70	.....	2.60	2.70	2.90	3.60	.....
22	2.60	3.15	2.80	4.78	4.00	3.40	.....	2.60	2.70	3.00	3.40	.....
23	2.60	3.00	2.80	4.79	3.90	3.40	.....	2.60	2.70	3.00	3.40	.....
24	2.55	3.30	2.85	4.75	4.00	3.40	.....	2.60	2.70	3.10	3.40	.....
25	2.65	3.50	2.80	4.72	4.50	3.40	.....	2.50	2.70	3.10	3.40	.....
26	2.60	3.50	2.90	4.71	4.80	3.40	.....	2.50	2.70	2.90	3.30	.....
27	2.70	3.60	2.90	4.10	5.20	3.30	2.30	2.60	2.70	3.10	3.30	.....
28	2.60	3.55	2.90	4.10	5.60	3.20	2.60	2.70	2.70	3.00	3.30	.....
29	2.60	.....	3.00	4.20	5.40	2.80	2.60	2.70	2.70	3.00	3.20	.....
30	2.60	.....	3.40	4.30	5.20	2.60	2.70	2.80	2.60	3.10	(a)	.....
31	2.60	.....	3.70	.....	5.00	.....	2.60	2.80	.....	3.00	.....	.....

[a] No record July 16 to 26 and November 30 to December 31.

Rating table for Truckee River at Vista, Nev., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	110	3.4	773	4.8	1,601	6.2	2,780
2.2	185	3.6	882	5.0	1,733	6.4	3,079
2.4	274	3.8	995	5.2	1,871	6.6	3,438
2.6	370	4.0	1,110	5.4	2,015	6.8	3,857
2.8	467	4.2	1,227	5.6	2,168	7.0	4,336
3.0	566	4.4	1,348	5.8	2,338		
3.2	668	4.6	1,473	6.0	2,537		

Estimated monthly discharge of Truckee River at Vista, Nev.

[Drainage area, 1,519 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	467	322	389	23,919	0.256	0.30
February	1,110	370	598	33,211	.393	.41
March	938	467	589	36,216	.388	.45
April	4,336	1,110	1,922	114,367	1.265	1.42
May	2,250	995	1,610	98,995	1.060	1.22
June	1,666	370	1,056	62,836	.695	.78
July	418	185	292	17,954	.192	.22
August	467	146	311	19,123	.205	.24
September	617	370	443	26,360	.292	.33
October	617	370	485	29,821	.319	.37
November 1 to 29	1,110	566	782	44,981	.515	.56

TRUCKEE RIVER AT NEVADA-CALIFORNIA STATE LINE, NEAR MYSTIC, CAL.

The gaging station on this river was established by L. H. Taylor September 7, 1899, at the State line, 17 miles west of Reno, Nev. The old gage was vertical, driven into the bed of the river, and wired to a granite bowlder. A new gage was established by E. C. Murphy November 11, 1902. It is a 4 by 4 inch timber in two parts and is located on the right bank 400 feet below the old gage. The lower section of the gage is inclined; the upper part is vertical. The zeros of the old and new gages coincide. The bench mark consists of two spikes driven into the root of the cottonwood tree to which the ver-

tical portion of the gage is attached. The elevation of the bench mark is 5.99 feet above the zero of the gage.

The following discharge measurements were made during 1902 by C. V. Taylor:

April 10: Gage height, 3.60 feet; discharge, 1,492 second-feet.
May 10: Gage height, 4.50 feet; discharge, 2,384 second-feet.

Daily gage height, in feet, of Truckee River at Nevada-California State line near Mystic, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.50	1.40	2.10	2.20	3.40	3.70	2.40	2.10	2.20	1.90	1.90	1.90
2	1.90	1.60	2.10	2.10	3.30	3.70	2.20	2.10	2.20	2.00	1.80	2.00
3	1.80	1.60	1.90	2.20	3.20	3.50	2.20	2.10	2.20	1.90	1.90	2.00
4	1.60	1.60	2.00	2.20	3.20	3.50	3.00	2.10	2.20	1.90	1.80	2.10
5	1.50	1.70	2.10	2.50	3.30	3.40	2.10	2.00	2.20	1.90	1.90	2.10
6	1.60	1.60	2.40	3.20	3.90	3.50	2.10	2.00	2.10	1.80	1.90	2.10
7	1.50	1.70	1.90	5.00	4.40	3.90	2.10	2.00	2.20	1.90	1.80	2.20
8	1.50	1.80	1.90	4.00	4.80	3.90	2.10	2.00	2.10	2.10	1.90	2.10
9	1.60	1.80	1.80	4.10	4.80	4.00	1.70	2.00	2.00	1.90	1.90	2.20
10	1.50	2.10	1.50	3.70	4.70	4.10	2.00	1.80	2.00	1.90	2.20	2.40
11	1.40	2.10	1.60	3.40	4.80	4.00	2.10	2.10	2.00	2.00	2.50	2.20
12	1.50	1.80	1.60	3.50	4.70	3.90	2.00	2.10	2.00	2.00	1.90	2.30
13	1.60	1.50	2.00	3.60	4.50	3.90	1.90	2.00	2.20	2.00	1.90	2.00
14	1.70	1.80	1.70	4.10	4.00	3.90	1.90	2.10	2.10	2.00	1.90	1.90
15	1.50	2.40	1.60	4.30	4.00	3.50	2.00	2.20	2.00	1.90	2.10	1.90
16	1.60	2.50	1.50	4.20	4.00	3.30	2.00	2.20	1.90	1.90	1.90	2.00
17	1.60	3.20	1.60	4.50	4.10	3.30	1.90	2.10	1.90	1.90	2.10	1.80
18	1.80	2.50	1.70	5.00	4.00	3.20	1.90	2.10	2.00	1.90	1.90	1.90
19	1.50	2.30	1.80	5.40	3.80	3.20	1.90	2.10	2.00	1.90	1.80	1.80
20	1.50	2.30	1.80	5.00	3.50	3.20	1.90	2.10	1.90	1.90	1.90	2.00
21	1.50	2.20	1.90	4.30	3.40	3.20	1.80	2.10	2.00	1.90	2.10	2.10
22	1.50	2.00	1.70	3.80	3.30	3.20	1.90	2.00	2.00	1.90	1.70	2.10
23	1.50	2.00	1.70	3.80	3.40	3.00	1.80	2.10	2.00	1.90	1.70	2.10
24	1.70	2.90	1.50	3.40	3.50	3.10	2.10	2.10	2.00	2.20	1.50	2.10
25	1.60	2.40	1.70	3.40	4.00	3.10	2.20	2.10	1.90	2.20	1.70	2.10
26	1.40	2.00	1.70	3.30	4.20	2.80	2.20	2.10	1.90	2.20	1.70	1.90
27	1.70	2.00	1.70	3.20	4.60	2.80	2.20	2.20	1.90	2.10	1.60	1.90
28	1.80	2.00	2.00	3.20	4.30	2.60	2.20	2.20	2.00	2.10	1.60	1.90
29	1.80	.....	2.00	3.40	4.70	2.50	1.90	2.20	2.00	2.00	1.80	1.90
30	1.70	.....	2.00	3.50	4.40	2.50	2.10	2.20	2.00	1.90	1.80	2.10
31	1.70	.....	2.10	.....	4.20	.....	2.20	2.20	.....	1.90	.....	2.10

Rating table for Truckee River at Mystic, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.4	268	2.6	795	3.8	1,683	5.0	3,002
1.6	319	2.8	924	4.0	1,870	5.2	3,283
1.8	383	3.0	1,055	4.2	2,069	5.4	3,596
2.0	463	3.2	1,194	4.4	2,280	5.6	3,953
2.2	559	3.4	1,345	4.6	2,505	5.8	4,370
2.4	671	3.6	1,508	4.8	2,745		

Estimated monthly discharge of Truckee River at Nevada-California State line near Mystic, Cal.

[Drainage area, 955 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	421	268	322	19,799	0.337	0.39
February	1,194	268	506	28,102	.530	.55
March	671	292	402	24,718	.421	.49
April	3,596	509	1,656	98,539	1.734	1.93
May	2,745	1,194	1,927	118,487	2.018	2.33
June	1,968	732	1,358	80,807	1.422	1.59
July	1,055	349	501	30,805	.525	.61
August	559	383	506	31,113	.530	.61
September	559	421	482	28,681	.505	.56
October	559	383	450	27,669	.471	.54
November	732	292	416	24,754	.436	.49
December	671	383	482	29,637	.505	.58
The year	3,596	268	751	543,111	.786	10.67

INDEPENDENCE CREEK BELOW INDEPENDENCE LAKE, NEAR OVERTON, CAL.

This station was established October 24, 1902, by E. C. Murphy. It is located about one-eighth of a mile below the dam at the end of Independence Lake, California. The gage is a vertical staff graduated to feet and tenths and is located about 200 feet upstream from the cable and car from which the measurements are made. The gage is read twice daily by James McNutt. The channel is straight both above and below the station. The banks are low, but not subject to overflow. The bed of the stream is permanent, being composed of gravel and clay. The bench mark is three nails driven in the root of a pine tree 55 feet northwest of the gage. Its elevation is 5.82 feet above the zero of the gage.

The following discharge measurement was made by E. C. Murphy in 1902:

October 24: Gage height, 1.23 feet; discharge, 0.27 second-foot.

Daily gage height, in feet, of Independence Creek below Independence Lake, near Overton, Cal.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	1.33	2.20	12	.....	1.93	1.60	23	.....	1.93	1.60
2	.....	1.33	2.20	13	.....	1.73	1.60	24	1.23	1.93	1.55
3	.....	1.33	2.00	14	.....	(a)	1.60	25	1.23	1.93	1.55
4	.....	1.23	1.95	15	.....	(a)	1.50	26	1.23	1.93	1.50
5	.....	1.23	1.90	16	.....	1.93	1.50	27	1.13	1.93	1.50
6	.....	1.13	1.90	17	.....	1.93	1.50	28	1.23	1.93	1.55
7	.....	1.23	1.80	18	.....	1.93	1.50	29	1.23	1.93	1.45
8	.....	1.33	1.80	19	.....	1.93	1.50	30	1.23	1.90	1.90
9	.....	1.18	1.80	20	.....	1.93	1.50	31	1.33	.....	1.90
10	.....	1.93	1.60	21	.....	1.93	1.50				
11	.....	1.93	1.60	22	.....	1.93	1.60				

a No record.

PROSSER CREEK NEAR BOCA, CAL.

This station was established October 23, 1902, by E. C. Murphy. It is located about 500 feet below the dam of the Prosser Creek Ice Company. It is about one-eighth of a mile above the mouth of the creek, at the footbridge between two ice houses. The gage is a vertical staff graduated to feet and tenths and located about 10 feet below the bridge. It is read twice daily by C. Lindsley. The channel is straight both above and below the station. The banks are high. The bed of the stream is permanent and is composed of sandy gravel and stone. The bench mark is a spike driven into the timber to which the gage is fastened. Its elevation is 6.0 feet above the zero of the gage.

The following discharge measurement was made in 1902 by E. C. Murphy:

October 23: Gage height, 0.85 foot; discharge, 21 second-feet.

Daily gage height, in feet, of Prosser Creek near Boca, Cal.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	0.75	0.80	12	.....	0.80	0.65	23	0.85	0.85	0.45
2	.....	.80	.80	13	.....	.85	.70	24	.95	.80	.45
3	.....	.75	.45	14	.....	.85	.65	25	.85	.80	.45
4	.....	.80	.65	15	.....	.85	.60	26	.85	.80	.35
5	.....	.80	.85	16	.....	.80	.55	27	.85	.80	.55
6	.....	.75	1.05	17	.....	.85	.65	28	.90	.85	.55
7	.....	.80	.95	18	.....	.85	.85	29	.85	.80	.45
8	.....	.70	1.00	19	.....	.80	.95	30	.85	.75	.40
9	.....	.70	1.10	20	.....	.80	.75	31	.80	.....	.45
10	.....	1.05	1.30	21	.....	.85	.75				
11	.....	1.00	.65	22	.....	.80	.55				

DONNER CREEK NEAR TRUCKEE, CAL.

This station was established October 23, 1902, by E. C. Murphy. It is located about 1½ miles west of Truckee, Cal., near the dam of the Donner Creek Ice Company. The gage is a vertical staff graduated to feet and tenths, located about 50 feet upstream from the cable from which measurements are taken. The gage is read twice daily by F. R. Williams. The channel is straight both above and below the station. The banks of the stream are high. The bed of the stream is permanent, being composed of gravel. The bench mark consists of four nails driven in the root of a pine tree 35 feet north of the gage. The elevation is 6.3 feet above the zero of the gage.

The following discharge measurement was made in 1902 by E. C. Murphy:

October 23: Gage height, 1.80 feet; discharge, 3.2 second-feet.

Daily gage height, in feet, of Donner Creek near Truckee, Cal.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	1.60	1.80	12	.....	1.85	1.95	23	1.80	1.90	1.80
2	.....	1.60	1.80	13	.....	1.85	1.80	24	1.82	1.90	1.85
3	.....	1.60	1.90	14	.....	2.20	1.90	25	1.72	1.90	1.90
4	.....	1.60	1.90	15	.....	1.85	1.90	26	1.60	1.90	1.80
5	.....	1.60	1.90	16	.....	2.00	1.90	27	1.60	1.90	1.80
6	.....	1.60	2.00	17	.....	1.90	1.95	28	1.60	1.90	1.75
7	.....	1.60	1.90	18	.....	2.20	1.90	29	1.65	1.90	1.85
8	.....	1.60	1.90	19	.....	1.90	1.80	30	1.70	1.80	2.25
9	.....	1.60	2.00	20	.....	1.80	1.80	31	1.60	.....	2.85
10	.....	2.05	2.00	21	.....	1.90	1.80				
11	.....	2.05	2.00	22	.....	1.90	1.80				

SUSAN RIVER NEAR SUSANVILLE, CAL.

The gaging station is about three-fourths of a mile southwest of the town, at the electric-light plant. It was established June 3, 1900, by L H. Taylor, a temporary gage being placed at the right bank of the river. The station is designed to be equipped with a cable and suspended car from which to make measurements of the discharge. The channel is straight for a distance above and below the station and the banks are high. The stream bed is of gravel and cobbles and is rather stable. The observer is James Branham.

A short distance above the station a small irrigating ditch, known as the Masten ditch, is taken out on the right bank of the stream. Near its head is a flume in which a gage has been placed and measurements are made.

Daily gage height, in feet, of Susan River near Susanville, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.40	2.40	3.80	3.80	4.42	4.02	2.80	1.90	1.75	1.90	2.10	2.20
2	2.40	2.45	3.70	3.75	4.40	3.92	2.98	1.90	1.75	1.90	2.10	2.30
3	2.40	2.50	3.70	3.80	4.32	3.85	2.88	1.85	1.75	1.90	2.10	2.30
4	2.40	2.55	3.65	3.95	4.30	3.75	2.80	1.85	1.75	1.90	2.10	2.22
5	2.40	2.60	3.60	4.15	4.30	3.65	2.80	1.85	1.75	2.20	2.15	2.30
6	2.40	2.65	3.40	4.32	4.45	3.55	2.75	1.85	1.70	2.20	2.15	2.35
7	2.40	2.70	3.40	5.80	4.65	3.52	2.70	1.85	1.70	2.20	2.20	2.45
8	2.40	2.80	3.35	4.95	4.78	3.48	2.50	1.85	1.70	2.20	2.20	2.55
9	2.40	3.30	3.30	4.68	4.75	3.42	2.38	1.80	1.70	2.20	2.20	2.55
10	2.40	3.50	3.35	4.58	4.75	3.40	2.35	1.80	1.70	2.20	2.65	3.60
11	2.40	3.60	3.35	4.50	4.70	3.62	2.32	1.80	1.70	2.20	2.40	3.50
12	2.40	3.50	3.40	4.50	4.65	3.30	2.30	1.80	1.70	1.95	2.30	3.10
13	2.40	3.20	3.45	4.65	4.60	3.48	2.30	1.80	1.70	1.95	2.28	3.00
14	2.40	3.10	3.55	4.72	4.60	3.65	2.30	1.80	1.75	1.95	2.22	2.85
15	2.40	4.10	3.55	4.90	4.55	3.62	2.25	1.80	1.75	1.95	2.20	2.55
16	2.40	3.90	3.55	5.08	4.48	3.52	2.20	1.85	1.75	1.95	2.28	2.50
17	2.40	4.40	3.85	5.10	4.40	3.40	2.20	1.90	1.75	1.95	2.32	2.40
18	2.40	4.20	3.60	5.25	4.32	3.32	1.95	1.90	1.75	1.95	2.42	2.40
19	2.40	4.10	3.75	5.60	4.32	3.28	1.95	1.90	1.75	2.00	2.40	2.30
20	2.40	3.90	3.75	5.50	4.20	3.22	1.95	1.90	1.75	2.00	2.40	2.30
21	2.40	4.10	3.70	5.25	4.08	3.20	1.90	1.85	1.80	2.00	2.35	2.40
22	2.40	4.00	3.60	5.05	3.98	3.12	1.90	1.85	1.80	2.10	2.33	2.40
23	2.40	3.90	3.60	4.85	3.92	3.07	1.90	1.85	1.85	2.15	2.30	2.45
24	2.40	4.20	3.50	4.85	3.90	3.00	1.90	1.85	1.85	2.15	2.30	2.50
25	2.40	4.10	3.35	4.65	3.90	2.95	1.90	1.80	1.85	2.20	2.25	2.50
26	2.40	3.90	3.30	4.55	3.92	2.90	1.90	1.80	1.90	2.20	2.22	5.05
27	2.40	4.10	3.35	4.50	4.05	2.90	1.90	1.80	1.90	2.20	2.20	4.75
28	2.40	3.90	3.45	4.42	4.02	2.82	1.90	1.75	1.90	2.20	2.20	4.60
29	2.40	.....	3.50	4.45	4.05	2.80	1.90	1.75	1.90	2.15	2.20	4.45
30	2.40	.....	3.50	4.50	4.05	2.80	1.90	1.75	1.90	2.15	2.20	4.20
31	2.40	.....	3.65	.....	4.05	.....	1.90	1.75	.....	2.10	.....	3.95

Miscellaneous measurements in Interior Basin.

HUMBOLDT RIVER BASIN.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1902.				*Sec.-feet.*
Apr. 22	C. V. Taylor	Humboldt River	Below Pitt dam, Nev	151.0
22	do	Irish American ditch	Near head-gates, Nev	34.7
July 28	D. W. Hays	do	do	28.3
Apr. 22	C. V. Taylor	Southwest ditch	Wagon bridge south of railroad, Nev.	30.3
July 22	D. W. Hays	do	At Railroad bridge, Nev	24.7
Apr. 23	C. V. Taylor	South Riverside ditch	At head-gates, Nev	5.4
23	do	Rodgers ditch	Flume across river	48.4
July 22	D. W. Hays	do	do	41.7
Apr. 23	C. V. Taylor	Union canal	Box near head	23.0
July 23	D. W. Hays	do	do	28.3

Miscellaneous measurements in Interior Basin—Continued.

WALKER RIVER BASIN.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1902.		*West Fork and tributaries.*		*Sec.-feet.*
Aug. 8	D. W. Hays	West Walker River	County bridge, Cal	222.0
July 26	L. H. Taylor	do	Hoys Bridge, Nev.	225.0
Aug. 7	D. W. Hays	do	do	72.0
Sept. 23	do	do	do	32.0
Oct. 4	do	do	do	44.0
July 24	L. H. Taylor	do	Lower end Smiths Valley, Nev.	180.0
Sept. 22	D. W. Hays	do	do	21.0
July 23	L. H. Taylor	do	Wilsons Ford, head of Mason Valley, Nev.	113.0
Sept. 10	D. W. Hays	Tunnel ditch	From West Walker, Mason Valley, Nev.	7.4
		East Walker and tributaries.		
Aug. 21	D. W. Hays	Robinson Creek	Below Twin Lakes, Cal	75.7
Oct. 6	do	do	do	24.0
Aug. 21	do	Buckeye Creek	Above all diversion, Cal	43.2
Oct. 4	do	do	do	20.0
7	do	Somers Creek	do	4.2
7	do	Green Creek	Above all diversion above Standard dam.	7.1
7	do	Dogtown Creek	Above all diversion, Cal	7.1
5	do	Swanger Creek	At bridge below Huntoon ranch, Cal.	5.7
July 23	L. H. Taylor	East Walker River	10 miles below Bridgeport, Cal.	196.0
Aug. 27	D. W. Hays	do	5 miles below Bridgeport, Cal.	80.0
Oct. 6	do	do	do	58.0
Aug. 28	do	Sweetwater Creek	East Walker River toll-road crossing, Nev.	.65
31	do	East Walker River	Webster's ranch, Nev	66.0
Sept. 6	do	do	do	42.0
July 23	L. H. Taylor	do	Strosnider's ranch, Nev	106.0
Sept. 11	D. W. Hays	Walker River	Nordyke, Nev	14.0
		Ditches from Walker River.		
July 23	L. H. Taylor	Meritt ditch	Mason Valley, Nev	11.9
23	do	Mason Slough	Headgates, Mason Valley, Nev.	63.8
23	do	Slough	At Mason's house, Nev	7.3

CARSON RIVER BASIN.

1902.		*Tributaries of East Fork.*		
Aug. 6	C. V. Taylor	Indian Creek	At head Cohn and Harvey ditch, Cal.	0.72
6	do	Hawkins Creek	¼ mile above Hawkins's house, Cal.	1.18
Sept. 9	L. L. Richard	do	do	1.10
Aug. 6	C. V. Taylor	Petersons Creek	Near old sawmill, Cal	1.27
Sept. 9	L. L. Richard	do	Above Cohn's meadow	.41
Aug. 5	C. V. Taylor	Long Valley Creek	Diamond Valley, Cal	4.12
5	do	do	Above Springmeyer's ranch, Nev.	2.48
5	do	do	Dam site of Long Valley reservoir site, Nev.	.51

Miscellaneous measurements in Interior Basin—Continued.

CARSON RIVER BASIN—Continued.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1902.		*Tributaries of West Fork.*		*Sec.-feet.*
Aug. 6	C. V. Taylor	Bruns Creek	Mouth of canyon, Cal	2.84
Sept. 9	L. L. Richard	do	do	3.48
Aug. 4	C. V. Taylor	Fairview Creek	Mouth of canyon, Nev	2.30
Sept. 8	L. L. Richard	do	do	2.60
Aug. 4	C. V. Taylor	Spring	¼ mile north of Heitman's house, Nev.	.74
4	do	do	Near Heitman's house, Nev	.35
Sept. 8	L. L. Richard	do	do	.27
Aug. 4	C. V. Taylor	do	South of Heitman's house, Nev.	1.08
Sept. 8	L. L. Richard	do	do	1.06
Aug. 4	C. V. Taylor	do	Heitmans, Nev	2.39
Sept. 8	L. L. Richard	do	do	2.35
Aug. 4	C. V. Taylor	S. Sheridan Creek	¼ mile from road, Nev	2.17
Sept. 8	L. L. Richard	do	Mouth of canyon, Nev	1.04
8	do	do	Above old house, Nev	1.35
Aug. 4	C. V. Taylor	Sheridan Creek	¼ mile above Sheridan, Nev	1.25
Sept. 8	L. L. Richard	do	Near old house, Nev	1.41
Aug. 4	C. V. Taylor	Parks Creek	In canyon, Nev	3.02
Sept. 8	L. L. Richard	do	Mouth canyon, Nev	3.17
8	do	Motts Creek	do	2.16
Aug. 4	C. V. Taylor	do	¼ mile above mouth canyon, Nev.	2.25
4	do	Kingsbury Creek	In canyon, Nev	1.20
Sept. 7	L. L. Richard	do	Bridge above old mill, Nev	1.12
Aug. 3	C. V. Taylor	Genoa Creek	Above all diversions, Nev	1.25
Sept. 7	L. L. Richard	do	Mouth of canyon, Nev	1.81
Aug. 3	C. V. Taylor	Dressler Creek	do	1.11
Sept. 7	L. L. Richard	do	do	.87
Aug. 3	C. V. Taylor	James Canyon Creek	do	.78
Sept. 11	L. L. Richard	do	Below Genoa road, Nev	.50
Aug. 3	C. V. Taylor	Jacks Valley Creek	Mouth of canyon, Nev	2.47
Sept. 7	L. L. Richard	do	Above Genoa road, Nev	.80
Aug. 2	C. V. Taylor	Pedrolis ditch	Pedrolis, Nev	.30
Sept. 11	L. L. Richard	do	do	.30
Aug. 2	C. V. Taylor	Clear Creek	do	2.02
Sept. 11	L. L. Richard	do	Above lower ditch, Nev	1.76
Aug. 2	C. V. Taylor	Kings Canyon Creek	Above all diversions, Nev	2.41
7	do	do	Robinsons Box, Nev	1.00
7	do	do	Mouth of canyon, Nev	2.71
Sept. 6	L. L. Richard	do	do	2.93
11	do	do	do	2.80
Aug. 10	C. V. Taylor	do	do	3.38
2	do	Ash Canyon Creek	¼ mile above mouth canyon, Nev.	2.76
Sept. 6	L. L. Richard	do	Mouth canyon, Nev	2.78
11	do	do	do	2.27
Aug. 7	C. V. Taylor	Walsh ditch		.07
7	do	Muldoon ditch	Head of ditch, Nev	.31
7	do	Water Co. ditch	do	.54
6	do	Thorn ditch	do	.46

SAN FRANCISCO BAY DRAINAGE BASIN.

Sacramento River, rising in northern California and flowing south, and the San Joaquin, rising in the southern sierras and flowing northeast, drain the western slope of the Sierra Nevada, traverse what is often called the Valley of California, and meet near Suisun Bay, finally discharging their waters into the Pacific Ocean through San Francisco Bay.

Sacramento River derives its water supply largely from Mount Shasta and the surrounding high ranges in the extreme northern portion of California. The stream does not have the same regular annual fluctuations that characterize the rivers discharging from the higher Sierra Nevada, in that a large part of its basin is not at an elevation sufficient to cause the winter snows to remain unmelted until the summer months. The greatest floods of this basin usually occur in January and February, when the snow is accompanied or followed by rain.

San Joaquin River is divided into two distinct parts. The valley portion forms the central drainage line of San Joaquin Valley, and during the spring is navigable for a hundred or more miles. The Stanislaus, Tuolumne, and King rivers are the largest affluents of this portion of the stream. Its valley is fertile and almost destitute of timber. The mountainous portion of the stream drains the western slopes of the Sierra Nevada between Yosemite National Park and Mount Goddard, the crest of its divide reaching an elevation on the north, in Mount Lyell, of 13,000 feet, and an elevation of 14,000 feet in Mount Goddard. The resulting steep grades of this river offer exceptional opportunities for water-power developments, and the high elevations of the basin insure a well-sustained summer flow from perpetual snow banks.

The following streams are tributary to either the Sacramento or San Joaquin rivers:

Cache Creek is the outlet of Clear Lake, in Lake County, Cal. Flowing southeasterly, its flood waters find their way into Sacramento River between the mouths of Feather and American rivers. In 1889 Clear Lake was segregated as a reservoir site, as described in the Thirteenth Annual Report, Part III, pages 405–409. During 1900 a hydrographic examination of the entire basin of Cache Creek was made by A. E. Chandler, whose detailed report has been published as Water-Supply Paper No. 45.

Feather River is the second largest tributary of Sacramento River, Pit River being the first. Its basin line follows the crest of the Sierra Nevada for about 130 miles. The rainfall in this basin is large; the mean for nineteen years at Mumfords Hill, Plumas County, is 71.64 inches; the rainfall for the year 1889–90 at this point reached 138.85 inches. The water collected by the river when rains are gen-

eral sometimes causes tremendous freshets, usually of short duration. The river has at such times overtopped its right bank and overflowed the plain lands to the northward of Sutter Buttes. This occurred even before the great reduction of waterway below the mouth of Yuba River. The channel of the river below its junction with the Yuba has become the repository of so much mining débris that its bed has become nearly filled. Its bottom is almost at the heights of its former banks. Levees have been built to prevent overflowing. There is a comparatively small portion of the summer flow of this stream used for irrigation, though the possibilities of irrigation and power development are great.

There are some excellent reservoir sites on the upper tributaries of the North Fork of the Feather. This stream is fed in part by large springs, one of which in Big Meadows was flowing 109 cubic feet per second in September, 1902, and another 64 cubic feet per second.

Stony Creek drains 760 square miles of the eastern slopes of the Coast Range. After reaching the Sacramento Valley it flows north for a number of miles, contrary to the general drainage, and then turns east and enters Sacramento River below Vina, Cal. A large portion of the basin near the heads of the stream is heavily covered with commercial timber. There are a number of good reservoir sites on this stream and its tributaries.

Tuolumne River rises on the western slope of the Sierra Nevada in California and drains the country between Stanislaus River on the north and Merced River on the south. The northern half of Yosemite National Park includes a portion of the drainage basin of this stream. The river is fed largely from small mountain lakes occurring high in the drainage basin, where the snow remains on the mountain slopes throughout the year, thus insuring a large run-off. The stream has a heavy fall, and the opportunities for power development are numerous. There are also a number of reservoir sites in the basin where flood water could be stored for use during the irrigation season. The Tuolumne is an important tributary of the San Joaquin.

Merced River above Merced Falls drains approximately 1,090 square miles of the western slopes of the Sierra Nevada. There are included in the eastern portion of its drainage area a large number of high peaks, the highest, Mount Lyell, reaching an elevation of 13,042 feet. Its basin lies south of that of the Tuolumne, the courses of the two streams being nearly parallel.

King River rises on the western slope of the Sierra Nevada, in Fresno County, Cal. The waters coming from the high catchment basin are probably of greater value for irrigation purposes than those of any other stream in central California, being used for raising grapes and deciduous fruits in the neighborhood of Fresno, Selma, and Hanford. The summer flow of the river is now entirely diverted, and during the dry season of the last few years the scarcity of water has

caused many hardships. In the spring there is a large surplus, due to the melting of snows, which, if stored in suitable reservoirs, would bring larger areas under cultivation. The river has a relatively gentle grade, affording little opportunity for power development.

Tule River drains a portion of the western slope of the Sierra Nevada. Its basin has somewhat less run-off than that of Kaweah River, which joins it on the north, and is much less elevated and snow covered than the King River Basin. The water of this stream is all appropriated during the irrigation season, and a portion is used in irrigating valuable orange lands in the vicinity of Portersville, Cal.

Kern River flows from the southern end of the Sierra Nevada, being formed by two large tributaries, known as the North and South forks. These have a general southerly and parallel course and unite a short distance below the town of Kernville. The run-off from the drainage basin as a whole is notably less than that from the catchment areas to the north. This is probably due to the fact that a portion of the basin is to the east of the high crest, and is sheltered by the mountain mass from the rain-bearing winds. The waters of Kern River are almost completely used for irrigation by the large canals in the southern end of the San Joaquin Valley. The greater part of the land is included in large holdings owned by the Kern County Land Company or by the Miller and Lux estate. The winter waters are in part stored by the Miller and Lux estate in Buena Vista Lake, into which the river naturally discharges. The waters of this lake are controlled by a system of levees, so that they can be used during the following summer to irrigate lands lying to the northwest. This lake is very broad and shallow and there is great loss by evaporation, so that as a matter of economy it would be desirable to hold this water in the upper mountain valleys. This would afford also a large supply for water power.

The fall of Kern River is sufficiently large for the development of a considerable amount of water power.

The following is a list of the stations in the San Francisco Bay drainage basin:

Cache Creek at Lower Lake, Cal.
Feather River at Oroville, Cal.
Stony Creek at Julians ranch, near Fruto, Cal.
Sacramento River at Jellys Ferry and at Iron Canyon, near Red Bluff, Cal.
Tuolumne River and Turlock Canal at Lagrange, Cal.
Merced River above Merced Falls, Cal.
King River at Kingsburg, Cal.
King River at Red Mountain, near Sanger, Cal.
Tule River near Portersville, Cal.
Kern River near Bakersfield, Cal.
San Joaquin River at Herndon, Cal.

CACHE CREEK AT LOWER LAKE, CAL.

On account of the great importance of Clear Lake as a storage reservoir, a gaging station was established at the wagon bridge across Cache Creek, one-half mile north of the town of Lower Lake, January 1, 1901. The observer is Mrs. J. R. Anderson.

Evaporation records have been kept at Lakeport on Clear Lake since February 1, 1901. The evaporation pan is 3 feet square and 1.5 feet deep and is floated on a triangular raft anchored in a cove where it is not exposed to the full force of the wind. Evaporation observations were begun on the land at the same point September, 1901. Capt. D. C. Rumsey is the observer. A table giving the evaporation, by months, from February, 1901, to December 31, 1902, will be found in the following pages.

Discharge measurements of Cache Creek at Lower Lake, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 29	J. R. Anderson	1.6	70
February 13	do	2.5	260
March 3	do	6.5	1,151
March 19	do	7.7	1,866
April 5	do	6.5	1,397
April 24	do	5.9	1,212
May 3	S. G. Bennett	5.2	1,042
May 19	J. R. Anderson	4.5	853
May 31	do	4.0	730
June 14	do	3.6	629
July 12	do	3.1	422
July 26	do	2.8	345
August 9	do	2.7	289
August 22	do	2.5	246
September 6	do	2.3	193
September 20	do	2.2	156
October 4	do	2.1	106
October 20	do	2.0	83
November 4	do	2.1	115
November 19	do	2.8	245
December 19	S. G. Bennett	2.8	301

Daily gage height, in feet, of Cache Creek at Lower Lake, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.6	1.6	5.9	6.5	5.4	•4.0	3.3	2.8	2.4	2.1	2.1	2.7
2	1.6	1.6	6.6	6.5	5.3	4.0	3.3	2.7	2.4	2.1	2.1	2.7
3	1.6	1.6	6.5	6.5	5.3	3.9	3.2	2.7	2.4	2.1	2.1	2.7
4	1.6	1.7	6.5	6.5	5.2	3.9	3.2	2.7	2.3	2.1	2.1	2.7
5	1.6	1.7	6.5	6.5	5.1	3.9	3.2	2.7	2.3	2.1	2.0	2.7
6	1.6	1.8	7.2	7.0	5.0	3.8	3.2	2.7	2.3	2.1	2.0	2.7
7	1.6	1.9	7.0	6.9	5.1	3.8	3.2	2.7	2.3	2.1	2.1	2.7
8	1.6	2.0	8.0	6.8	5.1	3.8	3.2	2.7	2.3	2.1	2.2	2.7
9	1.6	2.1	8.0	6.8	5.0	3.8	3.2	2.7	2.3	2.1	3.7	2.7
10	1.6	2.1	8.1	6.8	5.0	3.7	3.1	2.6	2.3	2.1	2.8	2.8
11	1.6	3.2	8.0	6.8	4.9	3.7	3.1	2.6	2.3	2.1	2.8	2.8
12	1.6	2.4	8.0	6.7	4.7	3.7	3.1	2.6	2.3	2.1	2.8	2.8
13	1.6	2.5	8.2	6.6	4.7	3.7	3.1	2.6	2.3	2.1	2.8	2.8
14	1.6	2.6	8.0	6.6	4.8	3.6	3.1	2.6	2.3	2.1	2.8	2.8
15	1.6	2.6	7.9	6.5	4.7	3.6	3.0	2.6	2.2	2.1	2.8	2.8
16	1.6	2.6	7.8	6.5	4.7	3.6	3.0	2.6	2.2	2.1	2.8	2.8
17	1.6	2.8	7.8	6.5	4.7	3.6	3.0	2.6	2.2	2.0	2.8	2.8
18	1.5	2.7	7.7	6.5	4.6	3.5	3.0	2.5	2.2	2.1	2.8	2.8
19	1.6	2.7	7.7	6.5	4.5	3.5	3.0	2.5	2.2	2.0	2.8	2.8
20	1.5	2.8	7.6	6.3	4.5	3.5	3.0	2.5	2.2	2.0	2.8	2.8
21	1.6	3.3	7.4	6.2	4.4	3.5	3.0	2.5	2.2	2.0	2.8	2.8
22	1.7	3.1	7.4	6.0	4.3	3.5	3.0	2.5	2.2	2.0	2.8	2.8
23	1.6	4.6	7.5	5.9	4.3	3.5	2.9	2.5	2.2	2.1	2.8	2.8
24	1.7	4.4	7.2	5.9	4.2	3.4	2.9	2.5	2.2	2.2	2.7	2.8
25	1.8	6.1	7.2	5.8	4.2	3.4	2.9	2.4	2.2	2.1	2.7	2.8
26	1.7	5.0	7.1	5.8	4.1	3.4	2.8	2.4	2.2	2.1	2.7	2.9
27	1.6	5.5	7.0	5.7	4.1	3.4	2.8	2.4	2.2	2.1	2.7	2.9
28	1.6	5.4	6.8	5.5	4.1	3.3	2.8	2.4	2.2	2.1	2.7	2.9
29	1.6	.....	6.7	5.5	4.1	3.3	2.8	2.4	2.1	2.1	2.7	2.9
30	1.6	.....	6.6	5.4	4.0	3.3	2.8	2.4	2.1	2.1	2.7	2.9
31	1.6	.....	6.5	.....	4.0	.....	2.8	2.4	.....	2.1	.....	2.9

Rating table for Cache Creek at Lower Lake, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.5	40	2.6	250	4.4	790	6.6	1,520
1.6	52	2.7	280	4.6	850	6.8	1,590
1.7	64	2.8	310	4.8	910	7.0	1,660
1.8	78	2.9	340	5.0	970	7.2	1,730
1.9	94	3.0	370	5.2	1,030	7.4	1,800
2.0	110	3.2	430	5.4	1,100	7.6	1,870
2.1	130	3.4	490	5.6	1,170	7.8	1,940
2.2	150	3.6	550	5.8	1,240	8.0	2,010
2.3	175	3.8	610	6.0	1,310	8.2	2,080
2.4	200	4.0	670	6.2	1,380		
2.5	225	4.2	730	6.4	1,450		

Estimated monthly discharge of Cache Creek at Lower Lake, Cal.

[Drainage area, 500 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	78	40	53	3,259	0.11	0.13
February	1,345	52	381	21,160	.76	.79
March	2,080	1,275	1,766	108,587	3.53	4.07
April	1,660	1,100	1,427	84,912	2.85	3.18
May	1,100	670	865	53,187	1.73	1.99
June	670	460	556	33,084	1.11	1.24
July	460	310	380	23,365	.76	.88
August	310	200	243	14,941	.49	.56
September	200	130	163	9,699	.33	.37
October	150	110	127	7,809	.25	.29
November	580	110	263	15,650	.53	.59
December	340	280	307	18,877	.61	.70
The year	2,080	40	544	394,530	1.09	14.79

Evaporation record of Clear Lake at Lakeport, Cal.

[D. C. Rumsey, observer.]

	Evaporation in inches.			Evaporation in inches.	
	Lake.	Land.		Lake.	Land.
1901.			1902.		
January (estimated)	0.85	.....	January	0.85	0.85
February	.95	.....	February	.25	.30
March	2.40	.....	March	1.60	1.55
April	3.05	.....	April	2.60	2.35
May	3.70	.....	May	4.00	3.70
June	3.95	.....	June	4.65	5.15
July	5.15	.....	July	6.65	7.40
August	5.00	.....	August	4.40	4.95
September	3.35	[a]1.6	September	4.10	4.40
October	2.30	2.45	October	1.95	1.85
November	.85	1.05	November	.45	.45
December	1.30	.95	December	.40	.45
	32.85	6.05		31.90	33.40

[a] September 15 to 29.

FEATHER RIVER AT OROVILLE, CAL.

At Oroville, where Feather River breaks from the foothills on the western slope of the Sierra Nevada into the Sacramento Valley, it has a drainage basin of 3,350 square miles.

The minimum midsummer discharge, as far as known, was in 1900 when the stream was flowing 1,123 second-feet. Observations of daily river stage were begun January 1, 1902, using the rod of the Weather Bureau, which has been in place for a number of years. Readings on this rod have been taken and reported by the Weather Bureau during flood heights when there was danger of overflow on the lower Feather and Sacramento rivers. It was found that there would be minus readings during low stage, and 2 feet have been added to the reading as observed on the rod. The observer is Miss Louise N. Lee.

Discharge measurements of Feather River at Oroville, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 29	S. G. Bennett	1.85	1,960
March 1	do	8.70	15,228
May 7	do	8.75	15,476
September 4	C. A. Miller	.96	1,385
September 10	do	.92	1,390
December 18	S. G. Bennett	3.65	3,298

Daily gage height, in feet, of Feather River at Oroville, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.0	2.0	10.7	6.5	8.6	7.5	2.9	1.4	1.0	0.8	1.2	[illegible]
2	2.5	2.0	10.5	7.0	7.5	7.0	3.0	1.4	1.0	.8	1.2	[illegible]
3	2.5	2.0	9.5	8.0	7.2	6.5	3.0	1.4	1.0	.8	1.2	[illegible]
4	2.0	2.0	8.8	10.0	7.1	6.3	3.0	1.3	.9	.8	1.2	[illegible]
5	2.0	3.0	8.5	13.0	7.0	6.2	3.0	1.3	.9	.8	1.2	[illegible]
6	2.0	3.5	8.3	14.0	8.0	6.2	2.9	1.3	.9	.8	1.4	[illegible]
7	2.0	9.0	8.1	14.0	8.5	6.0	2.7	1.3	.9	.8	2.0	[illegible]
8	2.0	10.2	8.2	12.3	8.4	6.0	2.5	1.3	.9	.8	3.3	[illegible]
9	2.0	11.3	8.8	11.2	8.4	5.9	2.5	1.3	.9	.8	3.9	[illegible]
10	2.0	10.5	8.4	10.6	8.4	5.8	2.4	1.3	.9	.8	8.5	[illegible]
11	2.0	9.7	8.5	9.2	8.3	5.8	2.4	1.3	.9	.8	5.3	[illegible]
12	2.0	9.8	7.4	8.9	8.7	5.7	2.3	1.3	.8	.8	3.8	[illegible]
13	2.0	8.3	6.9	8.7	9.0	5.5	2.2	1.3	.8	.8	3.3	[illegible]
14	2.0	7.2	6.7	8.6	8.8	5.4	2.2	1.3	.8	.8	3.5	[illegible]
15	2.0	11.8	6.4	9.9	8.5	4.7	2.1	1.3	.8	.8	3.4	[illegible]
16	2.0	11.3	6.4	11.5	8.4	5.0	2.0	1.3	.8	.8	3.4	[illegible]
17	2.0	12.5	6.5	11.0	8.3	4.8	1.9	1.3	.8	.8	4.0	[illegible]
18	2.0	10.2	6.7	10.5	7.8	4.5	1.9	1.3	.8	.8	5.5	[illegible]
19	2.0	9.2	6.6	9.5	7.5	4.3	1.8	1.3	.8	.8	6.5	[illegible]
20	2.0	8.5	6.8	9.4	7.3	4.3	1.8	1.3	.8	.8	5.5	[illegible]
21	2.0	9.0	6.8	9.8	7.0	4.1	1.7	1.3	.8	1.3	4.5	[illegible]
22	2.0	9.8	6.6	9.0	6.9	4.1	1.8	1.2	.8	1.8	3.2	[illegible]
23	2.0	9.5	6.5	9.5	6.8	4.0	1.7	1.2	.8	1.9	3.1	[illegible]
24	2.0	13.5	6.4	8.2	6.8	4.0	1.7	1.2	.8	3.3	3.1	[illegible]
25	2.0	13.0	6.3	7.8	7.5	3.8	1.6	1.1	.8	3.4	2.9	[illegible]
26	2.0	13.8	6.2	7.5	8.0	3.5	1.6	1.1	.8	1.2	2.5	[illegible]
27	2.0	13.7	6.1	7.4	7.9	3.4	1.6	1.1	.8	1.2	2.1	[illegible]
28	2.0	12.3	6.0	7.3	7.8	3.3	1.5	1.1	.8	1.2	1.9	[illegible]
29	2.0	.....	6.0	8.0	7.5	3.2	1.5	1.0	.8	1.2	1.7	[illegible]
30	2.0	.....	5.9	7.8	7.3	3.0	1.5	1.0	.8	1.2	1.5	[illegible]
31	2.0	.....	5.9	.....	7.0	.....	1.4	1.0	.....	1.2	.....	[illegible]

Rating table for Feather River at Oroville, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	1,300	3.0	2,750	5.2	5,660	9.5	18,900
1.0	1,400	3.2	2,950	5.4	6,020	10.0	21,200
1.2	1,510	3.4	3,150	5.6	6,400	10.5	23,500
1.4	1,620	3.6	3,365	5.8	6,800	11.0	25,800
1.6	1,735	3.8	3,595	6.0	7,200	11.5	28,100
1.8	1,855	4.0	3,825	6.5	8,300	12.0	30,400
2.0	1,975	4.2	4,095	7.0	9,500	12.5	32,700
2.2	2,115	4.4	4,365	7.5	10,900	13.0	35,000
2.4	2,255	4.6	4,660	8.0	12,500	14.0	39,600
2.6	2,410	4.8	4,980	8.5	14,400		
2.8	2,580	5.0	5,300	9.0	16,600		

Estimated monthly discharge of Feather River at Oroville, Cal.

[Drainage area, 3,350 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	2,325	1,975	1,998	122,852	0.60	0.69
February	38,680	1,975	19,545	1,085,474	5.83	6.07
March	24,420	7,000	11,148	685,464	3.33	3.84
April	39,600	8,300	19,485	1,159,438	5.82	6.49
May	16,600	9,020	12,110	744,615	3.61	4.16
June	10,900	2,750	5,609	333,759	1.67	1.86
July	2,750	1,620	2,098	129,001	.63	.73
August	1,620	1,400	1,535	94,383	.46	.53
September	1,400	1,300	1,323	78,724	.39	.44
October	3,150	1,300	1,503	92,416	.45	.52
November	14,400	1,510	3,481	207,134	1.04	1.16
December	25,800	1,565	6,287	386,573	1.88	2.17
The year	39,600	1,300	7,177	5,119,833	2.14	28.66

STONY CREEK NEAR FRUTO, CAL.

On January 30, 1901, a gaging station was established by Burt Cole at Julian's ranch, 6 miles northwest of the town of Fruto, Cal., to determine the amount of water available for storage. The observer is Mrs. Lee Julian.

During 1902 the following discharge measurements were made by S. G. Bennett:

January 26: Gage height, 3.90 feet; discharge, 126 second-feet.
February 28: Gage height, 10.00 feet; discharge, 7,336 second-feet.
May 8: Gage height, 5.33 feet; discharge, 1,080 second-feet.
September 24: Gage height, 3.00 feet; discharge, 14 second-feet.

Daily gage height, in feet, of Stony Creek at Julian's ranch, near Fruto, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.0	3.9	9.2	5.4	5.1	4.6	2.9	2.7	2.8	3.5	3.9	5.9
2	4.1	4.0	9.8	5.5	5.0	4.5	2.9	2.7	2.8	3.5	3.9	5.9
3	4.0	4.0	8.3	5.6	4.9	4.4	2.9	2.7	2.8	3.5	3.9	5.8
4	4.0	3.9	7.9	5.7	4.9	4.4	2.9	2.7	2.8	3.5	3.9	5.7
5	4.0	4.0	7.3	5.8	4.8	4.4	2.9	2.7	2.8	3.5	3.9	7.2
6	3.9	4.7	7.6	7.0	4.8	4.3	2.8	2.7	2.8	3.5	4.0	5.7
7	3.9	6.9	7.6	8.5	5.3	4.3	2.7	2.7	2.8	3.5	4.0	5.6
8	3.9	7.5	8.8	7.6	5.5	4.3	2.7	2.7	2.8	3.6	4.8	5.5
9	3.9	7.5	8.4	7.3	5.4	4.2	2.7	2.7	2.8	3.6	8.7	5.6
10	3.9	7.9	7.5	7.0	5.3	4.2	2.7	2.7	2.9	3.6	7.8	5.7
11	3.9	8.8	7.3	6.8	5.2	4.1	2.7	2.7	2.9	3.6	6.7	5.7
12	3.9	7.5	7.0	6.5	5.3	4.1	2.7	2.7	2.9	3.6	6.1	5.8
13	3.9	7.0	7.0	6.0	5.3	4.1	2.7	2.7	2.9	3.6	6.0	5.8
14	3.9	7.2	7.0	6.1	5.3	4.0	2.7	2.7	2.9	3.7	5.9	5.6
15	3.9	8.3	7.0	6.1	5.1	4.0	2.7	2.7	2.9	3.7	5.9	5.5
16	3.9	7.5	7.0	6.0	5.0	3.9	2.7	2.7	2.9	3.7	5.9	5.5
17	3.9	7.4	6.9	5.9	5.0	3.8	2.7	2.7	2.9	3.7	6.0	5.5
18	3.9	6.7	6.8	5.8	5.0	3.8	2.7	2.7	2.9	3.7	7.2	5.5
19	3.9	6.7	6.6	5.7	4.9	3.7	2.7	2.7	2.9	3.7	7.8	5.4
20	3.9	6.9	6.6	5.6	4.8	3.6	2.7	2.7	2.9	3.7	7.1	5.4
21	3.9	7.6	6.5	5.7	4.8	3.5	2.7	2.7	2.9	3.7	6.7	5.3
22	4.0	8.3	6.5	5.5	4.7	3.4	2.7	2.7	2.9	3.8	6.6	5.2
23	4.0	10.1	5.6	5.6	4.7	3.4	2.7	2.7	2.9	3.8	6.5	5.2
24	4.0	13.2	5.6	5.5	4.6	3.3	2.7	2.7	3.0	4.2	6.5	5.1
25	3.9	12.6	5.5	5.6	4.6	3.3	2.7	2.7	3.0	4.3	6.4	5.4
26	3.9	11.2	5.5	5.4	4.6	3.2	2.7	2.8	3.0	4.2	6.4	6.3
27	3.9	12.4	5.4	5.3	4.5	2.8	2.7	2.8	3.0	4.1	6.3	5.8
28	3.9	10.1	5.4	5.3	4.5	2.8	2.7	2.8	3.0	4.0	6.2	5.8
29	3.9	.....	5.4	5.2	4.4	2.8	2.7	2.8	3.0	4.0	6.1	5.9
30	3.9	.....	5.4	5.1	4.5	2.8	2.7	2.8	3.0	4.0	6.0	5.7
31	3.9	.....	5.4	.....	4.6	.....	2.7	2.8	.....	3.9	.....	5.6

Rating table for Stony Creek at Julian's ranch, near Fruto, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.8	5	4.6	370	6.4	1,835	8.5	4,680
3.0	14	4.8	490	6.6	2,050	9.0	5,510
3.2	27	5.0	620	6.8	2,275	9.5	6,410
3.4	44	5.2	765	7.0	2,510	10.0	7,400
3.6	67	5.4	920	7.2	2,765	10.5	8,400
3.8	94	5.6	1,080	7.4	3,035	11.0	9,450
4.0	125	5.8	1,250	7.6	3,315	11.5	10,550
4.2	185	6.0	1,430	7.8	3,605	12.0	11,700
4.4	270	6.2	1,625	8.0	3,900	13.0	14,150

Estimated monthly discharge of Stony Creek at Julian's ranch, near Fruto, Cal.

[Darinage area, 760 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	150	109	114	7,010	0.15	0.17
February	14,650	109	4,201	233,312	5.53	5.76
March	7,000	920	2,588	159,130	3.41	3.93
April	4,680	690	1,522	90,565	2.00	2.23
May	1,000	270	578	35,540	.76	.88
June	370	5	132	7,855	.17	.19
July	9	2	3	184	.00	.00
August	5	2	3	184	.00	.00
September	14	5	9	536	.01	.01
October	225	55	92	5,657	.12	.14
November	5,005	109	1,584	94,255	2.08	2.32
December	2,765	690	1,132	69,604	1.49	1.72
The year	14,650	2	997	703,832	1.31	17.35

SACRAMENTO RIVER AT JELLYS FERRY AND AT IRON CANYON, NEAR RED BLUFF, CAL.

The gaging station at Jellys Ferry, which is located 12 miles above the town of Red Bluff, was established April 30, 1895. The right bank of the river is high, but the left bank is liable to overflow when the river rises above the 25-foot mark. The river has been known to reach the 33-foot mark. Because of the liability to overflow, it was deemed advisable to select a new gaging station where the water at flood stage would be more confined. A point in Iron Canyon, where the river had been gaged by the State engineering department in 1879 and by the commissioner of public works in 1893–94, was chosen as a new gaging station. The river stage rod used by the commissioner of public works was still in place and has been used in making river height observations since January 28, 1902, the date upon which the observations were begun. The river at this point in lower portion of Iron Canyon, 4 miles above Red Bluff, has a direct course for 2 or 3 miles. The width between banks at low water is about 500 feet. The depth of water at low stages averages 6 feet with a maximum depth of 9 feet. The banks are steep and firm. The river flows in a bed of coarse gravel and cobbles with here and there a small bowlder. The bed

rock is lava. Discharge measurements are made from a cable 800 feet long, which is anchored in the lava rock that forms the wall of the canyon. The observer at Jellys Ferry was A. A. Sergison; at Iron Canyon, F. A. Wilcox.

Daily gage height, in feet, of Sacramento River at Jellys Ferry, near Red Bluff, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1902.						
1	5.7	5.5	19.6	9.0	11.4	8.3
2	6.0	5.8	21.3	9.1	10.5	8.1
3	6.3	5.5	16.7	9.7	9.9	7.9
4	5.8	6.5	15.3	11.2	9.7	7.6
5	5.8	8.1	14.2	10.9	9.4	7.6
6	5.8	9.4	17.6	11.3	9.6	7.6
7	5.7	16.0	15.8	18.3	11.5	7.5
8	5.7	21.9	19.8	17.6	11.1	7.7
9	5.7	25.2	21.9	14.5	10.7	7.7
10	5.7	32.6	17.1	13.0	10.5	7.6
11	5.6	29.6	15.1	12.4	10.2	7.6
12	5.6	26.0	14.0	11.5	9.9	7.4
13	5.6	19.3	15.1	11.0	10.6	7.3
14	5.5	18.3	12.6	10.9	11.7	7.3
15	5.5	23.8	11.9	10.9	12.3	7.0
16	5.6	22.6	11.4	10.8	11.1	6.9
17	5.5	23.1	11.1	10.9	10.6	6.8
18	5.5	20.9	10.9	10.9	10.2	6.7
19	5.4	17.5	11.0	11.3	9.7	6.6
20	5.5	15.5	10.4	11.0	9.4	6.5
21	5.9	17.1	10.6	10.6	9.1	6.5
22	5.9	20.8	10.2	10.1	8.9	6.5
23	5.8	21.2	10.3	9.8	8.8	6.4
24	6.2	32.7	9.9	9.6	8.8	6.4
25	5.9	32.0	9.6	9.8	8.8	6.3
26	5.7	28.8	9.4	9.3	8.8	6.3
27	5.6	25.9	9.2	9.2	9.1	6.2
28	5.5	21.3	9.0	8.9	9.1	6.1
29	5.5	.....	8.9	10.7	8.9	6.1
30	5.5	.....	8.9	10.4	8.5	6.0
31	5.5	.....	8.9	.....	8.4	.....

Rating table for Sacramento River at Jellys Ferry, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.0	2,400	6.8	8,070	12.0	24,400	22.0	76,800
4.2	2,670	7.0	8,630	12.5	26,400	23.0	83,400
4.4	2,970	7.2	9,200	13.0	28,400	24.0	90,000
4.6	3,290	7.4	9,800	13.5	30,400	25.0	96,600
4.8	3,630	7.6	10,400	14.0	32,400	26.0	103,200
5.0	3,980	7.8	11,000	14.5	34,600	27.0	109,800
5.2	4,360	8.0	11,600	15.0	36,800	28.0	116,400
5.4	4,760	8.5	13,100	15.5	39,200	29.0	123,000
5.6	5,170	9.0	14,600	16.0	41,600	30.0	129,600
5.8	5,590	9.5	16,100	17.0	46,600	31.0	136,200
6.0	6,030	10.0	17,600	18.0	52,300	32.0	142,800
6.2	6,500	10.5	19,200	19.0	58,200	33.0	149,400
6.4	7,000	11.0	20,800	20.0	64,200	34.0	156,000
6.6	7,530	11.5	22,600	21.0	70,400	35.0	162,600

Estimated monthly discharge of Sacramento River at Jellys Ferry, near Red Bluff, Cal.

[Drainage area, 9,134 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	6,750	4,760	5,376	330,557	0.59	0.68
February	147,420	4,965	69,423	3,855,558	7.60	7.91
March	76,160	14,300	31,213	1,919,213	3.42	3.94
April	54,070	14,300	22,096	1,314,803	2.42	2.70
May	25,600	12,800	17,453	1,073,143	1.91	2.20
June	12,500	6,030	8,758	521,137	.96	1.07

Discharge measurements of Sacramento River at Iron Canyon, near Red Bluff, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Second-feet.*
1901.			
October 30	S. G. Bennett	1.02	5,187
December 13	do	2.68	9,651
1902.			
January 28	do	1.35	5,912
February 12	Wm. F. Luning	20.60	110,824
March 3	S. G. Bennett	10.60	41,570
May 10	do	5.50	18,927
September 13	C. A. Miller	.84	4,425
December 31	S. G. Bennett	3.20	9,858

Daily gage height, in feet, of Sacramento River at Iron Canyon, near Red Bluff, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1		1.3	12.3	4.2	5.8	4.0	1.9	1.4	1.1	1.0	1.4	2.6
2		1.3	11.0	4.5	6.0	4.0	1.8	1.4	1.0	1.0	1.5	2.5
3		1.3	9.4	4.8	6.0	4.0	1.7	1.4	1.0	1.0	1.5	2.4
4		1.3	9.0	4.9	5.0	3.5	1.6	1.4	1.0	1.0	1.4	2.4
5		3.6	8.0	5.8	4.8	3.2	1.6	1.4	1.0	1.0	1.3	2.4
6		4.4	9.3	6.0	4.7	3.2	1.6	1.4	1.0	1.0	1.3	3.[illegible]
7		9.4	9.8	12.7	6.5	3.2	1.6	1.3	1.0	1.0	1.8	6.[illegible]
8		15.2	13.0	11.0	6.3	3.2	1.6	1.3	1.0	1.0	4.9	5.5
9		17.4	14.0	9.7	5.9	3.2	1.6	1.3	1.0	1.0	17.5	5.[illegible]
10		23.6	10.0	7.6	5.8	3.0	1.6	1.3	1.0	1.0	21.4	10.[illegible]
11		22.7	9.0	6.7	5.4	3.0	1.6	1.3	1.0	1.0	8.5	9.[illegible]
12		23.0	8.0	6.0	5.3	3.0	1.6	1.3	1.0	1.0	5.9	7.[illegible]
13		14.1	7.5	5.9	5.2	3.0	1.6	1.3	1.0	1.0	5.0	7.5
14		14.8	7.0	5.9	6.7	3.0	1.6	1.3	1.0	1.0	5.3	6.5
15		17.5	6.8	5.9	6.8	3.0	1.6	1.3	1.0	1.0	5.5	4.9
16		16.5	6.2	5.9	5.7	3.3	1.6	1.3	1.0	1.0	6.0	4.5
17		16.0	6.0	5.9	6.5	3.2	1.5	1.3	1.0	1.0	6.7	4.1
18		13.0	6.0	5.9	5.5	2.6	1.5	1.3	1.0	1.0	5.8	3.8
19		11.0	6.0	6.3	4.8	3.0	1.5	1.3	1.0	1.0	5.8	3.6
20		10.0	5.7	6.3	4.8	2.9	1.5	1.3	1.0	1.0	5.2	3.4
21		11.3	5.3	5.5	4.2	2.8	1.4	1.3	1.0	1.0	5.0	3.3
22		13.2	5.2	5.5	4.3	2.7	1.4	1.3	1.0	1.7	4.5	3.2
23		15.3	5.1	5.4	3.0	2.6	1.4	1.3	1.0	1.7	4.0	3.[illegible]
24		24.8	5.0	5.0	4.4	2.5	1.4	1.3	1.0	3.5	3.7	3.[illegible]
25		24.0	4.8	5.1	4.4	2.4	1.4	1.3	1.0	3.4	3.5	3.[illegible]
26		24.1	4.7	5.0	4.4	2.3	1.4	1.3	1.0	2.5	3.4	9.[illegible]
27		20.3	4.5	5.0	4.3	2.2	1.4	1.3	1.0	1.8	3.0	7.[illegible]
28	1.3	14.6	4.4	5.0	4.3	2.0	1.4	1.2	1.0	2.0	2.8	6.[illegible]
29	1.3	.....	4.3	4.5	4.2	1.9	1.4	1.2	1.0	1.7	2.7	5.1
30	1.3	.....	4.2	5.8	4.2	1.9	1.4	1.2	1.0	1.7	2.6	4.6
31	1.3	.....	4.2	.....	4.3	.....	1.4	1.2	.....	1.7	.....	4.6

Rating table for Sacramento River at Iron Canyon, near Red Bluff, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	5,000	5.0	17,100	9.0	34,300	13.0	55,600
1.2	5,440	5.2	17,900	9.2	35,260	13.2	56,800
1.4	5,880	5.4	18,700	9.4	36,220	13.4	58,000
1.6	6,340	5.6	19,500	9.6	37,180	13.6	59,220
1.8	6,820	5.8	20,300	9.8	38,140	13.8	60,460
2.0	7,300	6.0	21,100	10.0	39,100	14.0	61,700
2.2	7,840	6.2	21,940	10.2	40,100	14.5	64,900
2.4	8,380	6.4	22,780	10.4	41,100	15.0	68,200
2.6	8,950	6.6	23,620	10.6	42,120	15.5	71,600
2.8	9,550	6.8	24,460	10.8	43,160	16.0	75,100
3.0	10,150	7.0	25,300	11.0	44,200	16.5	78,600
3.2	10,790	7.2	26,180	11.2	45,280	17.0	82,200
3.4	11,430	7.4	27,060	11.4	46,360	18.0	89,700
3.6	12,090	7.6	27,940	11.6	47,460	19.0	97,600
3.8	12,770	7.8	28,820	11.8	48,580	20.0	105,900
4.0	13,450	8.0	29,700	12.0	49,700	21.0	114,600
4.2	14,150	8.2	30,620	12.2	50,860	22.0	123,700
4.4	14,850	8.4	31,540	12.4	52,020	23.0	133,200
4.6	15,580	8.6	32,460	12.6	53,200	24.0	143,100
4.8	16,340	8.8	33,380	12.8	54,400	25.0	153,400

Estimated monthly discharge of Sacramento River at Iron Canyon, near Red Bluff, Cal.

[Drainage area, 9,295 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January [a]	6,750	4,760	5,376	330,557	0.59	0.68
February	151,320	5,660	69,154	3,840,619	7.44	7.75
March	61,700	14,150	27,371	1,682,977	2.94	3.39
April	53,800	14,150	21,992	1,308,615	2.37	2.64
May	24,460	10,150	17,803	1,094,664	1.92	2.21
June	13,450	7,060	9,998	594,922	1.08	1.20
July	7,060	5,880	6,192	380,731	.67	.77
August	5,880	5,440	5,674	348,881	.61	.70
September	5,220	5,000	5,007	297,937	.54	.60
October	11,750	5,000	5,931	364,683	.64	.74
November	118,200	5,660	19,767	1,176,218	2.13	2.38
December	39,100	8,110	17,506	1,076,402	1.88	2.17
The year	151,320	4,760	17,648	12,497,206	1.90	25.23

[a] Discharge at Jellys Ferry for January.

TUOLUMNE RIVER AT LAGRANGE, CAL.

The station, established August 29, 1895, is located at the wagon bridge in the town of Lagrange, Cal. It is below the high dam of the Turlock and Modesto irrigation districts and also below the head of the canal of the Lagrange Ditch and Hydraulic Mining Company, which diverts water from the left bank of the river 15 miles above Lagrange dam. The flow through this canal for 1902 was between 4 and 5 cubic feet per second.

The channel at the gaging station, both above and below the bridge, is straight for several hundred feet and the velocity of the stream is quite uniform. Both banks are high and not subject to overflow. For the last few years the channel seems to be gradually washing out. The observer is Annie P. McGinn.

During 1902 the following discharge measurements were made by S. G. Bennett and L. M. Lawson:

	Second-feet.
March 6:	
Gage height, 6.00 feet; discharge	2,351
Turlock Canal	103
Lagrange Ditch and Hydraulic Mining Company's canal	5
Total	2,459
May 13:	
Gage height, 8.35 feet; discharge	9,476
Turlock Canal	253
Lagrange Ditch and Hydraulic Mining Company's canal	5
Total	9,734
August 27:	
Gage height, 3.50 feet; discharge	15
Turlock Canal	105
Lagrange Ditch and Hydraulic Mining Company's canal	4
Total	124

Daily gage height, in feet, of Tuolumne River at Lagrange, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.4	4.4	6.0	5.6	6.8	7.7	6.2	4.4	3.5	3.6	4.4	4.6
2	4.3	4.4	6.7	5.6	6.6	7.2	6.1	4.4	4.0	3.7	4.4	4.6
3	5.0	4.4	6.5	5.5	6.6	7.1	5.9	4.2	4.2	3.6	4.4	4.5
4	5.1	4.4	6.1	5.6	6.5	7.4	5.9	4.1	4.0	3.6	4.3	4.6
5	4.8	4.4	5.9	5.8	6.8	7.7	5.5	4.0	4.0	3.6	4.3	4.8
6	4.6	4.3	5.9	6.6	7.0	7.9	5.5	3.8	4.0	3.6	4.4	5.2
7	4.5	4.4	5.8	9.2	7.4	7.7	5.3	3.9	4.0	3.6	4.4	5.3
8	4.4	4.4	6.3	8.9	8.1	8.0	5.2	3.8	3.9	3.7	4.3	5.1
9	4.5	4.9	7.4	7.6	8.4	8.9	5.3	4.1	3.9	3.7	4.4	5.1
10	4.7	4.8	6.6	7.1	8.4	8.7	5.4	4.0	3.9	3.7	5.9	5.0
11	4.6	4.8	6.1	6.9	8.3	8.4	5.4	3.8	4.0	3.6	6.2	6.2
12	4.5	4.8	6.1	6.8	8.0	8.6	5.3	4.0	4.0	3.6	5.6	5.8
13	4.5	4.8	6.0	6.9	7.7	8.5	5.3	4.1	3.9	3.6	5.2	5.5
14	4.5	4.8	5.9	7.1	7.4	8.0	5.2	4.1	4.0	3.7	5.1	5.4
15	4.5	5.0	5.7	7.2	7.3	7.8	5.1	4.2	4.0	3.7	4.9	5.3
16	4.4	5.6	5.7	7.3	7.4	7.7	5.2	4.1	3.9	3.7	4.9	5.1
17	4.4	5.5	5.7	7.4	7.5	7.6	5.1	4.0	4.0	3.6	4.7	5.0
18	4.4	5.4	5.8	7.6	7.5	7.3	4.9	3.9	3.9	3.6	4.8	4.9
19	4.4	5.4	5.7	7.8	7.2	7.4	4.9	3.9	3.9	3.6	4.8	4.9
20	4.3	5.3	5.5	8.5	6.6	7.5	5.0	3.8	4.0	3.6	5.0	4.8
21	4.4	5.2	5.5	8.0	6.2	7.6	5.0	3.7	4.0	3.5	4.9	4.7
22	4.3	5.7	5.5	7.6	6.1	7.5	4.9	3.5	3.9	3.5	4.9	4.8
23	4.2	5.5	5.7	7.2	6.3	7.5	4.8	3.4	3.8	3.6	4.8	4.9
24	4.3	5.8	5.7	6.9	6.8	7.3	4.8	3.4	3.9	3.7	4.9	4.9
25	4.4	6.4	5.5	6.0	7.1	7.1	4.8	3.5	3.8	4.8	4.9	4.9
26	4.5	7.3	5.5	6.0	8.0	7.0	4.8	3.5	3.8	4.6	4.8	5.0
27	4.4	7.7	5.4	5.6	8.5	6.8	4.7	3.5	3.8	4.5	4.8	5.0
28	4.3	7.6	5.5	6.0	8.9	6.4	4.6	3.4	3.8	4.6	4.8	4.9
29	4.4	.....	5.7	6.1	8.6	6.4	4.7	3.3	3.7	4.5	4.9	4.9
30	4.4	.....	5.7	6.5	8.8	6.4	4.7	3.5	3.7	4.6	4.8	4.8
31	4.3	.....	5.6	.....	8.9	.....	4.5	3.4	.....	4.5	.....	4.8

Rating table for Tuolumne River at Lagrange, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.4	7	5.0	750	6.6	3,610	8.2	8,580
3.6	25	5.2	950	6.8	4,100	8.4	9,350
3.8	55	5.4	1,180	7.0	4,630	8.6	10,140
4.0	115	5.6	1,480	7.2	5,200	8.8	10,950
4.2	200	5.8	1,850	7.4	5,810	9.0	11,780
4.4	300	6.0	2,260	7.6	6,450	9.2	12,630
4.6	410	6.2	2,690	7.8	7,120	9.4	13,500
4.8	560	6.4	3,140	8.0	7,830		

TURLOCK CANAL.

The Turlock canal, the property of the Turlock Irrigation District, takes water from the left bank of the Tuolumne River at the Lagrange dam. This canal was designed to carry 1,500 second-feet and to irrigate a large area of fertile land in the vicinity of Turlock and Ceres, Stanislaus County, Cal. During 1898 water was first turned into the canal in small quantities and used for puddling the banks. A record of the gage height has been kept since July, 1899. Meter measurements are made when the gaging station on Tuolumne River at Lagrange is visited, and Morgan flume, or flume No. 2, has been rated. The observer is J. L. Montgomery.

During 1902 the following discharge measurements were made by S. G. Bennett and L. M. Lawson:

May 13: Gage height, 2.92 feet; discharge, 253 second-feet.
July 23: Gage height, 3.00 feet; discharge, 260 second-feet.
Aug. 27: Gage height, 2.60 feet; discharge, 105 second-feet.

Daily gage height, in feet, of Turlock canal at Lagrange, Cal.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1902.							
1	(a)	3.1	0.0	3.7	3.8	3.9	[illegible]
2	.....	3.1	0.0	3.7	3.8	3.9	[illegible]
3	.....	3.1	3.0	3.7	3.8	3.7	
4	.....	3.1	3.0	3.7	3.8	3.7	
5	.....	3.1	3.4	3.7	3.8	3.7	
6	.....	3.1	3.5	3.7	3.8	3.8	
7	2.3	3.2	3.5	3.7	3.9	3.9	
8	2.0	3.2	3.5	3.7	4.0	3.9	
9	0.0	3.2	3.5	3.7	4.0	3.9	
10	0.0	3.2	3.5	3.7	4.0	3.9	
11	2.4	3.2	3.5	3.7	4.0	4.0	
12	2.6	3.2	3.5	3.7	4.0	4.0	
13	2.6	3.2	3.0	3.7	4.0	4.0	
14	2.0	3.2	3.0	3.7	4.0	3.8	
15	2.8	3.2	3.0	3.7	4.0	3.8	
16	2.8	3.2	3.0	3.7	4.0	3.8	
17	0.0	3.2	3.6	3.7	3.2	3.8	
18	3.0	2.5	3.6	3.7	2.7	4.0	
19	3.1	2.5	3.6	3.7	3.6	3.9	
20	3.1	2.4	3.6	3.7	3.6	3.9	
21	3.1	3.4	3.6	3.7	3.6	3.7	
22	3.1	3.4	3.6	3.8	3.6	3.6	
23	3.1	3.4	3.6	3.8	3.6	3.4	
24	3.1	3.4	3.6	3.8	3.6	3.5	
25	3.1	3.5	3.6	3.8	3.6	3.5	
26	3.1	3.5	3.6	3.8	3.6	2.8	
27	3.1	3.5	3.3	3.8	3.6	2.8	
28	0.0	0.0	2.9	3.8	3.6	2.7	
29	0.0	0.0	3.6	3.8	3.6	2.7	
30	2.4	0.0	3.6	3.8	3.6	2.6	
31	3.0	.....	3.6	.....	3.6	2.6	

[a] No record Jan. 1 to Mar. 6. [b] Sept. 2 to Dec. 31 no water in canal; making repairs

Rating table for Turlock canal at Lagrange, Cal., for 1902.

MARCH 7 TO JULY 31.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	113	2.5	182	3.0	268	3.5	360
2.1	125	2.6	198	3.1	286	3.6	380
2.2	138	2.7	215	3.2	304	3.7	400
2.3	152	2.8	232	3.3	322	3.8	420
2.4	166	2.9	250	3.4	340	4.0	460

APPROXIMATE TABLE FOR AUGUST.

2.6	105	3.0	175	3.4	247	3.8	327
2.7	122	3.1	193	3.5	267	3.9	347
2.8	139	3.2	211	3.6	287	4.0	367
2.9	157	3.3	229	3.7	307		

Estimated monthly discharge of Tuolumne River at Lagrange, Cal.

[Drainage area, 1,501 square miles.]

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1902.			
January	850	200	352
February	6,780	250	1,443
March	5,810	1,180	2,103
April	12,630	1,320	4,735
May	11,360	2,470	6,334
June	11,360	3,140	6,519
July	2,690	350	998
August	300	0	91
September	200	35	89
October	560	15	113
November	2,690	250	676
December	2,690	350	809
The year	12,630	0	2,022

Estimated monthly discharge of Turlock canal at Lagrange, Cal.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
1902.			
January	0	0	[illegible]
February	0	0	[illegible]
March	286	0	[illegible]
April	360	0	[illegible]
May	380	0	[illegible]
June	420	400	[illegible]
July	460	215	[illegible]
August	367	105	[illegible]
September	47	0	[illegible]
October	0	0	[illegible]
November	0	0	[illegible]
December	0	0	[illegible]
The year	460	0	[illegible]

Estimated monthly combined discharge of Tuolumne River and Turlock canal at Lagrange, Cal.

[Drainage area, 1,501 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	850	200	352	21,644	0.23	0.27
February	6,780	250	1,443	80,140	.96	1.00
March	5,810	1,320	2,290	140,807	1.53	1.76
April	12,934	1,606	5,003	297,699	3.33	3.71
May	11,740	2,850	6,656	409,262	4.43	5.11
June	11,760	3,560	6,925	412,066	4.61	5.14
July	3,110	730	1,403	86,267	.93	1.07
August	647	112	378	23,242	.25	.29
September	200	35	91	5,415	.06	.07
October	560	15	113	6,948	.08	.09
November	2,690	250	676	40,225	.45	.50
December	2,690	350	809	49,743	.54	.62
The year	12,934	15	2,178	1,573,458	1.45	19.63

MERCED RIVER ABOVE MERCED FALLS, CAL.

The measurement of this stream was undertaken in response to numerous requests from mining and irrigation interests. The midsummer flow of the stream is less than the combined capacity of the irrigation and power canals taking water in the vicinity of Snelling. The gaging station at a point 1 mile above Merced Falls was established April 6, 1901. Meter measurements are made from a cable. The observer is Charles Siegfeldt.

During 1902 the following discharge measurements were made by S. G. Bennett and L. M. Lawson:

March 6: Gage height, 10.10 feet; discharge, 1,302 second-feet.
May 13: Gage height, 12.15 feet; discharge, 5,413 second-feet.
September 3: Gage height, 8.10 feet; discharge, 109 second-feet.

Daily gage height, in feet, of Merced River above Merced Falls, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.6	8.4	10.5	9.7	10.8	11.6	10.0	8.7	8.1	7.8	8.1	8.5
2	8.7	8.5	12.3	9.8	10.8	11.4	9.9	8.7	8.0	7.8	8.1	8.5
3	9.1	8.5	11.0	9.7	10.9	11.3	9.8	8.6	8.1	7.8	8.1	8.5
4	8.9	8.5	10.5	9.6	10.9	11.4	9.6	8.6	8.1	7.8	8.1	8.5
5	8.9	8.5	10.2	9.7	11.1	11.9	9.5	8.5	8.1	7.8	8.1	8.3
6	8.8	8.5	10.1	9.9	11.4	12.0	9.4	8.5	8.1	7.8	8.0	8.6
7	8.8	8.5	10.0	11.8	11.5	12.0	9.3	8.5	8.0	7.8	8.0	8.9
8	8.7	8.6	10.0	12.4	11.9	12.3	9.3	8.6	8.0	7.8	8.1	8.8
9	8.7	8.7	12.5	11.8	12.4	12.4	9.3	8.5	8.0	7.8	8.1	10.2
10	8.7	8.7	11.5	11.5	12.4	12.3	9.3	8.8	8.0	7.9	8.4	8.8
11	8.6	8.6	10.6	11.0	12.0	12.1	9.4	8.8	8.0	7.8	10.0	9.3
12	8.6	8.7	10.4	10.8	12.2	12.1	9.3	8.9	8.0	7.8	9.2	9.5
13	8.7	8.8	10.1	10.9	12.3	11.9	9.3	8.9	8.0	7.8	8.8	9.2
14	8.6	8.8	10.1	11.0	11.6	11.4	9.3	8.7	8.0	7.8	8.7	9.0
15	8.7	8.7	9.7	11.2	11.3	11.4	9.2	8.7	8.0	7.8	8.7	8.8
16	8.6	8.9	9.6	11.1	11.1	11.2	9.2	8.5	8.0	7.9	8.6	8.8
17	8.6	9.2	9.7	11.3	11.6	11.1	9.1	8.5	7.8	7.8	8.6	8.7
18	8.6	9.3	9.8	11.8	11.8	11.1	8.9	8.4	7.9	7.8	8.6	8.7
19	8.6	9.1	9.6	12.2	11.2	11.1	9.0	8.4	8.0	7.8	9.3	8.7
20	8.6	9.0	9.6	11.9	11.0	11.1	8.9	8.4	8.0	7.8	9.0	8.5
21	8.6	9.0	9.6	11.4	10.8	11.1	9.0	8.3	8.1	7.8	8.8	8.6
22	8.5	9.5	9.4	10.9	10.8	11.0	8.9	8.3	8.0	7.8	8.8	8.6
23	8.5	9.4	9.4	10.8	11.0	10.9	8.9	8.2	8.0	7.9	8.7	8.6
24	8.5	10.5	9.5	10.7	11.3	10.7	8.9	8.2	7.9	8.2	8.7	8.6
25	8.6	10.8	9.4	10.5	11.9	10.6	8.9	8.2	7.9	8.8	8.6	8.6
26	8.6	11.3	9.3	10.5	11.7	10.5	8.9	8.2	7.8	8.4	8.6	8.6
27	8.5	11.8	9.3	10.5	12.4	10.4	8.8	8.2	7.9	8.4	8.5	8.7
28	8.5	11.3	9.2	10.4	12.7	10.1	8.9	8.1	7.9	8.3	8.7	8.8
29	8.5	.....	9.4	10.5	12.7	10.1	8.8	8.1	7.9	8.2	8.6	8.7
30	8.5	.....	9.5	10.8	12.6	10.2	8.8	8.1	7.8	8.1	8.6	8.6
31	8.5	.....	9.6	.....	12.4	.....	8.8	8.1	.....	8.1	.....	8.6

Rating table for Merced River above Merced Falls, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
7.8	65	8.9	320	10.0	1,110	11.2	2,840
7.9	75	9.0	360	10.1	1,220	11.4	3,200
8.0	90	9.1	410	10.2	1,340	11.6	3,590
8.1	110	9.2	460	10.3	1,470	11.8	4,020
8.2	130	9.3	520	10.4	1,600	12.0	4,480
8.3	150	9.4	580	10.5	1,740	12.2	4,960
8.4	170	9.5	650	10.6	1,880	12.4	5,460
8.5	195	9.6	730	10.7	2,030	12.6	5,980
8.6	220	9.7	810	10.8	2,180	12.8	6,500
8.7	250	9.8	900	10.9	2,340		
8.8	280	9.9	1,000	11.0	2,500		

Estimated monthly discharge of Merced River above Merced Falls, Cal.

[Drainage area, 1,090 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	410	195	236	14,511	0.22	0.25
February	4,020	170	749	41,597	.69	.72
March	5,720	460	1,364	83,869	1.25	1.44
April	5,460	730	2,457	146,202	2.25	2.51
May	6,240	2,180	3,795	233,345	3.48	4.01
June	5,460	1,220	3,142	186,962	2.88	3.21
July	1,110	280	481	29,576	.44	.51
August	320	110	191	11,744	.18	.21
September	110	65	88	5,236	.08	.09
October	280	65	90	5,534	.08	.09
November	1,110	90	246	14,638	.23	.26
December	1,340	195	303	18,631	.28	.32
The year	6,240	65	1,095	791,845	1.01	13.62

KING RIVER AT KINGSBURG, CAL.

This station was established in 1879 by the engineering department of the Southern Pacific Company. No meter measurements have been made since 1898 except a low-water measurement in 1902, because it was found impossible to construct a satisfactory rating table, on account of the changes in gage heights caused by the raising and lowering of the head gate of the Peoples Canal, which takes water from King River a few miles below the gaging station. The gage heights for 1902 have been furnished by William Hood, chief engineer of the Southern Pacific Company. Alf. Thompson was the observer.

Daily gage height, in feet, of King River, at Kingsburg, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.8	3.3	4.3	4.1	3.8	7.5	3.8	2.7	1.6	1.3	1.8	4.7
2	3.8	3.3	3.3	4.2	3.8	6.7	3.6	2.7	1.7	1.3	1.7	4.7
3	3.8	3.3	6.3	3.8	3.5	6.1	3.4	2.7	1.6	1.3	1.7	4.8
4	4.4	3.4	4.3	3.8	3.7	7.3	2.8	2.5	1.6	1.3	1.7	4.8
5	4.4	3.4	3.3	3.8	3.8	8.0	2.3	2.5	1.6	1.3	2.0	4.8
6	4.3	3.4	3.1	3.8	4.7	8.4	2.0	2.4	1.6	1.3	2.3	4.8
7	4.3	3.5	4.5	3.6	4.8	9.0	2.0	2.3	1.6	1.3	2.5	4.8
8	4.3	3.6	4.3	3.8	6.1	9.3	1.9	2.5	1.6	1.3	2.8	4.8
9	4.0	3.7	4.9	5.9	7.8	9.4	2.7	2.4	1.6	1.3	3.3	4.9
10	3.9	3.6	6.0	4.8	7.7	9.3	2.9	2.4	1.7	1.3	3.9	5.0
11	3.9	3.5	4.8	4.1	7.5	8.8	3.6	2.3	1.7	1.3	5.3	5.1
12	3.8	3.5	4.2	3.6	7.8	9.5	4.1	2.3	1.7	1.3	4.9	5.1
13	3.8	3.6	3.8	3.7	8.3	9.5	4.3	2.3	1.7	1.3	4.5	5.0
14	3.8	3.7	4.3	3.9	7.3	8.3	3.9	2.2	1.7	1.3	4.9	5.0
15	3.7	3.5	4.2	4.3	6.3	7.7	3.6	2.2	1.7	1.3	4.9	5.1
16	3.4	3.5	3.8	4.1	5.6	7.5	3.3	2.1	1.7	1.3	4.8	5.1
17	3.4	3.6	3.8	4.5	6.3	7.0	3.3	2.0	1.7	1.3	4.6	5.0
18	3.4	3.7	3.9	5.3	7.3	6.8	3.2	1.9	1.7	1.3	4.5	5.0
19	3.3	3.7	4.2	6.5	6.1	6.8	3.3	1.8	1.7	1.3	4.6	5.0
20	3.3	3.5	4.3	5.9	5.5	6.7	2.8	1.8	1.6	1.3	4.8	5.0
21	3.3	3.5	3.9	5.1	4.8	6.7	2.9	1.8	1.6	1.3	5.1	4.8
22	3.2	3.7	3.7	5.3	4.3	6.5	2.8	1.8	1.6	1.3	4.8	4.8
23	3.3	3.8	3.4	3.1	4.4	6.0	2.8	1.8	1.6	1.4	4.9	5.0
24	3.3	3.8	3.5	3.3	4.9	5.8	2.8	1.8	1.4	1.4	4.8	5.0
25	3.3	5.6	3.5	3.3	6.1	5.3	2.8	1.8	1.4	1.7	4.8	4.9
26	3.4	6.1	3.3	2.8	6.3	5.1	2.8	1.8	1.5	2.6	4.7	5.0
27	3.5	5.9	3.3	2.7	7.0	4.7	3.0	1.8	1.5	2.4	4.7	5.0
28	3.3	6.1	3.3	2.8	8.5	4.2	3.0	1.8	1.4	2.5	4.8	5.1
29	3.4	.....	3.3	2.8	9.0	3.9	3.1	1.7	1.3	2.5	4.7	5.0
30	3.4	.....	3.6	2.8	9.0	3.9	3.0	1.6	1.3	2.5	4.7	4.9
31	3.4	.....	4.0	.....	8.8	.....	2.8	1.6	.....	1.8	.....	4.9

KING RIVER AT RED MOUNTAIN, NEAR SANGER, CAL.

The gaging station at Red Mountain, established September 3, 1895, is located 15 miles east of Sanger, Cal., and is near the mouth of the canyon and above all diversions. The bed of the stream is in gravel and few changes have been noted in the cross section since the establishment of the station. For the last three years the station has been considered as rated for all gage heights up to 11 feet, and few meter measurements have been made. The present rating will probably hold good until a change in the channel is caused by a violent flood. The observer is O. G. Williams.

The following discharge measurement was made in 1902 by L. M. Lawson:

September 21: Gage height, 4.00 feet; discharge, 217 second-feet.

Daily gage height, in feet, of King River at Red Mountain, near Sanger, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
1902.												
1	4.4	4.1	5.6	6.1	7.7	8.9	7.8	5.2	4.1	3.8	4.0	4.2
2	4.4	4.2	8.3	6.1	7.8	8.9	7.8	5.2	4.0	3.8	4.0	4.3
3	4.4	4.2	6.6	6.0	8.0	9.1	7.1	5.1	4.0	3.8	3.9	4.3
4	4.4	4.1	5.9	6.1	8.1	9.9	6.7	5.0	4.0	3.7	3.9	4.3
5	4.5	4.2	5.8	6.1	8.3	10.0	6.5	4.9	4.0	3.7	3.9	4.2
6	4.4	4.2	5.8	6.1	8.9	10.0	6.4	4.9	4.0	3.7	3.9	4.3
7	4.4	4.3	5.8	13.1	8.6	10.7	6.4	5.0	4.0	3.7	3.9	4.4
8	4.4	4.3	5.6	9.1	9.3	10.7	6.5	5.1	3.9	3.7	3.8	4.4
9	4.4	4.3	7.4	8.0	9.6	11.0	6.5	5.2	4.0	3.7	3.9	4.3
10	4.3	4.2	6.3	7.7	9.8	10.9	6.4	5.2	3.9	3.7	4.0	4.5
11	4.3	4.3	5.9	7.5	9.4	10.4	6.6	5.1	4.0	3.7	5.6	5.4
12	4.4	4.2	5.8	7.6	10.0	10.9	6.3	5.0	3.9	3.7	4.9	5.2
13	4.4	4.2	5.7	7.7	10.0	11.0	6.4	5.0	4.0	3.7	4.6	4.9
14	4.3	4.2	5.7	7.9	9.3	10.1	6.2	5.0	4.0	3.7	4.5	4.5
15	4.3	4.2	5.5	8.1	8.8	10.0	6.1	4.9	4.0	3.8	4.5	4.4
16	4.3	4.3	5.5	8.2	8.8	10.0	6.0	4.7	4.0	3.7	4.3	4.4
17	4.3	4.5	5.5	8.4	9.3	9.6	5.9	4.7	4.1	3.7	4.3	4.3
18	4.3	4.8	5.7	8.7	9.4	9.6	5.8	4.6	4.0	3.7	4.3	4.4
19	4.2	4.6	5.7	9.2	8.6	9.6	5.7	4.5	4.0	3.7	4.3	4.4
20	4.2	4.4	5.7	9.0	8.2	9.7	5.6	4.5	4.0	3.7	4.7	4.3
21	4.2	4.5	5.6	8.1	7.9	9.7	5.7	4.4	4.0	3.7	4.4	4.4
22	4.2	4.7	5.6	7.9	8.0	9.3	5.6	4.3	3.9	3.7	4.4	4.3
23	4.2	4.9	5.6	7.4	8.4	8.9	5.5	4.3	3.9	3.7	4.4	4.3
24	4.3	4.8	5.5	7.4	8.6	9.0	5.5	4.2	3.9	4.5	4.4	4.3
25	4.2	5.5	5.5	7.3	9.2	9.0	5.5	4.2	3.9	4.4	4.4	4.4
26	4.3	7.3	5.5	7.1	9.1	8.7	5.4	4.1	3.9	4.1	4.4	4.3
27	4.3	6.6	5.4	7.1	9.7	8.4	5.5	4.1	3.8	4.1	4.4	4.4
28	4.2	5.8	5.5	7.2	10.3	7.9	5.6	4.1	3.8	4.1	4.4	4.3
29	4.2	.....	5.5	7.3	11.1	8.1	5.5	4.1	3.8	4.1	4.3	4.3
30	4.1	.....	5.9	7.9	10.6	8.0	5.4	4.0	3.8	4.1	4.3	4.3
31	4.1	.....	6.0	.....	10.4	.....	5.4	4.1	.....	4.0	.....	4.2

Rating table for King River at Red Mountain, near Sanger, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.6	180	5.8	1,310	8.0	3,920	10.2	9,610
3.8	250	6.0	1,450	8.2	4,300	10.4	10,400
4.0	320	6.2	1,642	8.4	4,680	10.6	11,300
4.2	400	6.4	1,834	8.6	5,096	10.8	12,250
4.4	480	6.6	2,034	8.8	5,548	11.0	13,240
4.6	572	6.8	2,242	9.0	6,000	11.2	14,300
4.8	676	7.0	2,450	9.2	6,520	11.4	15,440
5.0	780	7.2	2,718	9.4	7,040	11.6	16,660
5.2	910	7.4	2,986	9.6	7,600	11.8	17,930
5.4	1,040	7.6	3,280	9.8	8,220	12.0	19,230
5.6	1,170	7.8	3,600	10.0	8,900		

Estimated monthly discharge of King River at Red Mountain, near Sanger, Cal

[Drainage area, 1,742 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	520	360	440	27,055	0.25	0.29
February	2,852	360	665	36,932	.38	.40
March	4,490	1,040	1,420	87,312	.82	.95
April	26,380	1,450	4,163	247,716	2.39	2.67
May	13,760	3,440	6,532	401,637	3.75	4.32
June	13,240	3,760	8,063	479,782	4.63	5.16
July	3,600	1,040	1,638	100,717	.94	1.08
August	910	320	626	38,491	.36	.42
September	360	250	304	18,089	.17	.19
October	520	215	265	16,294	.15	.17
November	1,170	250	451	26,836	.26	.29
December	1,040	400	497	30,559	.29	.33
The year	26,380	215	2,089	1,511,420	1.20	16.27

TULE RIVER NEAR PORTERSVILLE, CAL.

The gaging station is located about 8 miles east of Portersville, at a point just below the wagon bridge near the McFarland ranch and about 1 mile above the mouth of the South Fork of Tule River. The

station was established April 18, 1901. The gage rod is situated on the right bank of the river 100 feet below the bridge. The zero of the gage is 8 feet below a spike driven into a large cottonwood tree. The observer is Adah McFarland.

Discharge measurements of Tule River near Portersville, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Second-feet.*
1901.			
June 28	A. E. Chandler	2.00	1[illegible]
1902.			
February 5	S. G. Bennett	1.33	4
March 8	do	2.20	1[illegible]
May 15	do	3.03	3[illegible]
October 2	L. M. Lawson	.92	1[illegible]

Daily gage height, in feet, of Tule River near Portersville, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.35	1.35	2.40	2.60	2.90	2.80	1.60	1.10	0.98	0.92	1.18	1.[illegible]
2	1.35	1.35	4.40	2.70	2.90	2.70	1.55	1.10	.98	.92	1.18	1.[illegible]
3	1.35	1.35	2.80	2.50	2.80	2.60	1.55	1.10	.96	.90	1.18	1.[illegible]
4	1.35	1.35	2.40	2.65	2.80	2.80	1.55	1.10	.94	.90	1.15	1.[illegible]
5	1.30	1.35	2.30	2.70	2.80	2.70	1.50	1.08	.94	.92	1.15	1.[illegible]
6	1.30	1.40	2.20	2.65	2.85	2.60	1.50	1.08	.92	.92	1.15	1.[illegible]
7	1.30	1.40	2.20	7.20	2.90	2.60	1.50	1.05	.92	.94	1.15	1.[illegible]
8	1.30	1.40	2.20	4.00	2.90	2.60	1.45	1.05	.92	.96	1.15	1.[illegible]
9	1.30	1.40	5.60	3.70	3.00	2.60	1.50	1.03	.92	.98	1.15	1.[illegible]
10	1.35	1.40	3.00	3.50	3.00	2.55	1.40	1.08	.92	1.00	1.40	1.[illegible]
11	1.35	1.35	2.80	3.40	3.10	2.45	1.35	1.08	.90	1.02	2.00	2.[illegible]
12	1.40	1.35	2.60	3.30	3.00	2.35	1.35	1.08	.90	1.04	1.70	1.[illegible]
13	1.40	1.35	2.50	3.20	3.05	2.35	1.30	1.06	.90	1.04	1.50	1.[illegible]
14	1.35	1.40	2.40	3.10	3.00	2.30	1.30	1.06	.90	1.03	1.45	1.[illegible]
15	1.30	1.40	2.30	3.15	3.00	2.25	1.25	1.06	.90	1.03	1.40	1.[illegible]
16	1.25	1.40	2.20	3.20	3.00	2.15	1.20	1.06	.90	1.02	1.35	1.[illegible]
17	1.30	1.40	2.00	3.30	3.00	2.10	1.20	1.06	.92	1.02	1.35	1.[illegible]
18	1.35	1.40	2.20	3.30	2.95	2.10	1.20	1.06	.92	1.02	1.35	1.[illegible]
19	1.40	1.45	2.50	3.40	2.90	2.05	1.20	1.06	.94	1.00	1.70	1.[illegible]
20	1.40	1.60	2.40	3.50	2.80	2.00	1.20	1.06	.96	1.00	1.55	1.[illegible]
21	1.35	1.60	2.35	3.70	2.70	1.90	1.20	1.06	.95	.98	1.50	1.[illegible]
22	1.35	2.00	2.25	3.00	2.65	1.85	1.20	1.08	.95	.96	1.45	1.[illegible]
23	1.35	1.75	2.35	3.00	2.65	1.80	1.20	1.08	.95	.94	1.40	1.[illegible]
24	1.40	1.80	2.35	3.00	2.60	1.75	1.18	1.04	.95	1.70	1.40	1.[illegible]
25	1.40	1.85	3.00	2.90	2.65	1.75	1.15	1.04	.95	1.40	1.40	1.[illegible]
26	1.40	4.20	3.00	2.85	2.75	1.70	1.18	1.02	.95	1.30	1.35	1.[illegible]
27	1.40	4.40	3.00	2.80	2.80	1.70	1.20	1.02	.95	1.25	1.35	1.[illegible]
28	1.35	2.70	2.60	2.85	3.00	1.65	1.20	1.01	.95	1.25	1.35	1.[illegible]
29	1.35	.....	2.30	2.90	2.90	1.60	1.18	1.00	.94	1.20	1.35	1.[illegible]
30	1.35	.....	2.30	2.90	2.80	1.60	1.15	1.00	.94	1.20	1.35	1.[illegible]
31	1.35	.....	2.50	.....	2.80	.....	1.14	1.00	.....	1.20	.....	1.[illegible]

Rating table for Tule River near Portersville, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.7	9	1.7	93	2.7	298	3.7	685
.8	11	1.8	109	2.8	324	3.8	770
.9	14	1.9	126	2.9	351	3.9	875
1.0	18	2.0	144	3.0	379	4.0	980
1.1	23	2.1	163	3.1	408	4.1	1,085
1.2	30	2.2	183	3.2	440	4.2	1,195
1.3	39	2.3	204	3.3	475	4.3	1,305
1.4	51	2.4	226	3.4	515	4.4	1,415
1.5	64	2.5	249	3.5	560	4.5	1,525
1.6	78	2.6	273	3.6	615		

Estimated monthly discharge of Tule River near Portersville, Cal.

[Drainage area, 437 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	51	34	45	2,767	0.10	0.12
February	1,415	45	159	8,830	.36	.37
March	2,735	144	362	22,259	.83	.96
April	4,615	249	571	33,977	1.31	1.46
May	408	273	343	21,090	.79	.91
June	324	78	190	11,306	.43	.48
July	78	26	43	2,644	.10	.12
August	23	18	21	1,291	.05	.06
September	17	14	15	893	.03	.03
October	93	14	24	1,476	.05	.06
November	144	27	50	2,975	.11	.12
December	204	45	62	3,812	.14	.16
The year	4,615	14	157	113,320	.36	4.85

KERN RIVER NEAR BAKERSFIELD, CAL.

This station, established in 1893 by Walter Jones, chief engineer of the Kern County Land Company, is located at what is known as First Point of Measurement, 5 miles above Bakersfield and at the mouth of the canyon of the river. Miscellaneous meter measurements are taken, and an automatic gage records daily fluctuations of the river heights. A. K. Warren, the engineer in charge of this work for the Kern County Land Company, attends to the discharge measurements with accuracy and precision, and furnishes the Geological Survey with the final results.

Daily discharge, in second-feet, of Kern River at first point of measurement.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	287	258	863	850	1,615	2,306	1,314	433	201	184	237	[illegible]
2	291	268	1,119	893	1,559	2,028	1,269	402	198	190	237	[illegible]
3	291	277	1,493	849	1,522	1,811	1,205	373	198	187	241	[illegible]
4	290	270	929	831	1,504	1,904	1,090	337	191	183	230	[illegible]
5	289	260	756	930	1,520	2,018	989	333	186	172	237	[illegible]
6	293	253	772	1,078	1,589	2,215	915	338	186	168	246	[illegible]
7	312	251	725	1,647	1,704	2,527	839	328	184	162	249	[illegible]
8	314	262	620	3,438	1,765	2,608	766	327	187	167	243	[illegible]
9	307	260	717	2,461	1,880	2,701	740	366	186	185	243	[illegible]
10	290	263	957	2,000	2,004	2,726	747	374	191	190	269	[illegible]
11	287	254	787	1,836	2,065	2,735	736	369	189	185	300	[illegible]
12	274	252	770	1,748	2,108	2,642	712	386	195	180	393	[illegible]
13	264	254	782	1,752	2,156	2,910	722	385	198	186	340	[illegible]
14	274	254	790	1,806	2,135	2,755	711	346	191	190	306	[illegible]
15	282	251	723	1,877	1,997	2,400	704	340	206	186	285	[illegible]
16	286	259	645	2,008	1,797	2,313	675	330	214	194	273	[illegible]
17	286	263	655	2,130	1,827	2,244	631	321	227	195	262	[illegible]
18	289	260	728	2,332	1,884	2,195	603	319	223	190	265	[illegible]
19	294	268	790	2,620	1,868	2,159	588	307	216	193	281	[illegible]
20	292	257	813	2,807	1,697	2,169	550	295	200	195	298	[illegible]
21	296	258	758	2,740	1,549	2,159	522	279	198	194	313	[illegible]
22	291	279	751	2,303	1,447	2,173	509	278	203	197	298	[illegible]
23	281	339	759	2,030	1,403	2,119	505	258	204	200	315	[illegible]
24	278	353	794	1,772	1,451	1,887	508	253	198	214	322	[illegible]
25	285	379	734	1,682	1,555	1,836	484	254	194	237	310	[illegible]
26	272	871	694	1,559	1,673	1,726	466	228	197	262	288	[illegible]
27	255	1,252	689	1,505	1,662	1,561	469	224	200	236	292	[illegible]
28	247	1,451	667	1,556	1,780	1,410	430	220	179	236	301	[illegible]
29	260	.....	681	1,530	2,120	1,431	501	223	176	242	289	[illegible]
30	259	.....	735	1,540	2,250	1,293	480	218	179	236	277	[illegible]
31	250	.....	779	.....	2,320	.....	460	209	.....	236	.....	[illegible]

Estimated monthly discharge of Kern River at first point of measurement.

[Drainage area 2,345 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	321	242	283	17,401	0.12	0.14
February	1,828	243	371	20,604	.16	.17
March	2,029	601	790	48,575	.34	.39
April	3,758	799	1,805	107,405	.77	.86
May	2,405	1,375	1,787	109,878	.76	.88
June	3,096	1,235	2,165	128,826	.92	1.03
July	1,354	453	706	43,410	.30	.35
August	453	205	312	19,184	.13	.15
September	232	174	197	11,722	.08	.09
October	292	161	199	12,236	.09	.10
November	413	225	281	16,721	.12	.13
December	346	231	269	16,540	.11	.13
The year	3,758	161	764	552,502	.33	4.42

SAN JOAQUIN RIVER AT HERNDON, CAL.

This station was established in 1879 by the engineering department of the Southern Pacific Company. The river bed at this point is composed of small gravel and shifting sand. Because of the continual changes in the cross section, which were increased by a side channel breaking through the gravel pits on the left bank of the river just above the gaging station, meter measurements were discontinued at this station at the end of 1901.

The river stage record for 1902 has been furnished by William Hood, chief engineer of the Southern Pacific Company. G. G. Nelson was the observer.

Daily gage height, in feet, of San Joaquin River at Herndon, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.												
1	2.7	2.5	4.8	4.3	6.0	8.5	5.8	3.5	3.0	2.8	2.6	[illegible]
2	2.7	2.5	4.5	4.4	6.3	7.5	5.7	3.5	3.0	2.8	2.6	[illegible]
3	2.7	2.5	5.6	4.2	6.2	7.5	5.5	3.5	3.0	2.8	2.6	[illegible]
4	2.7	2.5	4.3	4.3	5.7	7.0	5.0	3.5	2.9	2.8	2.6	[illegible]
5	2.6	2.5	4.0	4.4	5.5	7.3	4.5	3.4	2.9	2.8	2.5	[illegible]
6	2.6	2.5	3.7	4.5	6.0	7.8	4.3	3.4	2.9	2.7	2.5	[illegible]
7	2.6	2.5	3.5	6.7	6.5	8.0	4.3	3.4	2.9	2.7	2.5	[illegible]
8	2.6	2.5	4.0	8.0	6.7	8.5	4.3	3.4	2.8	2.7	2.5	[illegible]
9	2.6	2.5	4.0	7.0	6.7	9.0	4.1	3.4	2.8	2.7	2.5	[illegible]
10	2.5	2.5	4.7	6.5	6.8	8.8	4.1	3.8	2.8	2.7	2.5	[illegible]
11	2.5	2.5	4.3	6.2	7.0	8.5	4.0	3.7	2.8	2.7	4.3	[illegible]
12	2.5	2.5	4.0	5.7	7.6	9.3	4.5	3.7	2.8	2.7	3.8	[illegible]
13	2.5	2.5	4.0	5.5	7.8	9.0	4.5	3.6	2.8	2.7	3.7	[illegible]
14	2.5	2.7	3.8	6.0	7.4	8.5	4.5	3.5	2.8	2.7	3.4	[illegible]
15	2.5	2.7	3.8	6.2	6.9	8.1	4.6	3.5	2.8	2.6	3.3	[illegible]
16	2.5	2.6	3.8	6.3	6.4	7.8	4.3	3.5	2.8	2.6	3.2	[illegible]
17	2.5	2.8	3.7	6.4	6.7	7.5	4.0	3.3	2.8	3.6	3.1	[illegible]
18	2.5	2.7	3.7	6.5	7.1	7.5	4.0	3.3	2.8	2.6	2.8	[illegible]
19	2.5	2.8	3.7	7.8	6.6	7.2	4.0	3.3	2.8	2.6	2.8	[illegible]
20	2.5	2.8	3.8	7.3	6.5	7.1	4.0	3.3	2.8	2.5	2.8	[illegible]
21	2.5	2.8	3.8	7.0	6.2	7.0	4.0	3.2	2.8	2.5	2.8	[illegible]
22	2.5	2.8	3.7	6.5	6.0	7.4	4.3	3.2	2.8	2.5	2.8	[illegible]
23	2.5	3.0	3.7	5.7	6.0	7.0	3.8	3.2	2.8	2.5	2.8	[illegible]
24	2.5	3.0	3.7	5.5	6.5	7.0	3.8	3.2	2.8	2.5	2.8	[illegible]
25	2.6	4.5	3.7	5.3	6.8	7.0	3.8	3.2	2.8	2.5	2.8	[illegible]
26	2.6	5.0	3.7	5.1	7.2	6.8	3.8	3.2	2.8	2.5	2.8	[illegible]
27	2.6	4.8	3.6	5.0	7.7	6.5	3.7	3.1	2.8	2.8	2.7	[illegible]
28	2.5	5.0	3.6	5.0	8.3	6.8	3.7	3.1	2.8	2.8	2.7	[illegible]
29	2.5	.....	3.6	5.0	8.3	6.0	3.6	3.0	2.8	2.7	2.7	[illegible]
30	2.5	.....	3.6	5.0	8.6	6.0	3.6	3.0	2.8	2.7	2.7	[illegible]
31	2.5	.....	4.0	.....	8.8	.....	3.6	3.0	.....	2.7	.....	[illegible]

Miscellaneous measurements in San Francisco Bay drainage basin.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Second-feet.*
Sept. 22	Sacramento	Upper Soda Creek, Castle Crags	.....	15[illegible]
22	do	Upper Bairds station	.....	28[illegible]
24	McCloud	Vanardsdale clubhouse, 1 mile above Squaw Creek.	.....	1,35[illegible]
24	Squaw Creek	Squaw Creek Bridge, Vanardsville road	.....	6[illegible]
		Total McCloud	.....	1,36[illegible]
23	do	Hirze Mountain	.....	1,2[illegible]
26	do	Baird post-office, U. S. fisheries	.....	1,35[illegible]
17	Pit	Bridge above mouth of Fall River	.....	3[illegible]
16	do	Fall River at bridge, Fall River Mills	.....	1,54[illegible]
16	do	Hat Creek at bridge, Carbon post-office	.....	58[illegible]
15	do	At Pecks Bridge	.....	2,3[illegible]
15	do	Burney, ¼ mile below falls	.....	39[illegible]
27	do	Squaw Creek near mouth, Copper City	.....	[illegible]
27	do	Silverthorn Ferry, Copper City	.....	2,3[illegible]
14	Sacramento	Balls Ferry Bridge	.....	4,4[illegible]

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Sec.-feet.*
Sept. 15	Sacramento	Battle Creek Bridge, near Balls Ferry		313.0
14	do	Ditch, Battle Creek, Balls Ferry Flour Mills		27.0
		Total Battle Creek		340.0
25	do	Sacramento	a 7.22	5,848.0
8	Feather, North Fork	East Branch, Hamilton Bridge, Big Meadows.		163.0
8	do	Big Spring Branch, 1 mile below boathouse, Big Meadows.		64.0
9	do	West Branch, ¼ mile below bridge, Bunnell Hotel, Prattville.		327.0
5	do	Iron bridge near Meadow View Hotel, ¼ mile below junction of east and west branches.		607.0
9	do	Dotta or Lower Big Spring, near mouth Big Meadows.		109.0
8	do	Bidwell's sawmill, lower end of Big Meadows.		669.0
7	do	Butt Valley Creek, near Butt Valley Hotel		27.0
5	do	Indian Valley at bridge, lower end of valley		22.0
4	do	Spanish Creek at "Pocket Bridge," lower end of American Valley, near Quincy, Cal.		28.0
9	do	Huff Bar, Big Bend		595.0
12	do	Big Bend Tunnel, above Huff Bar		315.0
		Total Big Bend		910.0
4	do	West Branch, 300 feet above Yankee Hill Bridge.		27.0
4	Feather, Middle Fork	Above mouth of Nelson Creek		59.0
4	do	Nelson Creek, just above mouth		33.0
		Total below Nelson Creek		92.0
6	do	At mouth		215.0
3	Feather, South Fork	In Little Grass Valley		1.0
6	do	At Enterprise		1.0
6	do	Palermo canal at Enterprise		30.0
6	do	Bidwell Bar		216.0
		Total		246.0
25	Cache Creek	Yolo Bridge, 5 miles from Woodlands	1.4	56.0
1	Yuba, North Fork	Bay Counties Power Co.'s flume, below dam		221.0
1	do	Below Bay Counties Power Co.'s dam		2.0
		Total		223.0
Aug. 30	Yuba, Middle Fork	¼ mile below Delhi mine		52.0
Sept. 1	do	300 feet below Freemans Bridge		64.0
Aug. 30	Yuba, South Fork	North Bloomfield ditch at North Columbia, water from Bowman's reservoir.		7.0
30	do	Eureka Lake Co.'s ditch, North Columbia, water from French and Faucherie lakes.		9.0
29	do	Edwards Bridge		59.0
30	do	Bridgeport Bridge		55.0
30	do	Excelsior Mining and Irrigation Co.'s canal, Pleasant Valley.		32.0
		Total		87.0
Sept. 1	Yuba	Above bridge, 4 miles below Smartsville		487.0

a U. S. Weather Bureau gage. Highest water mark, 28.6 feet December 27, 1892; lowest water mark 0.0 foot October 23, 1856.

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Sec. ft.*
Aug. 25	Bear	Below dam of South Yuba Water Co.		[illegible]
	do	Old mining ditch, ¼ mile below Headworks.		[illegible]
		Total flow mouth of Greenhorn River.		[illegible]
26	do	Old mining ditch, near Auburn.		[illegible]
25	American, North Fork	200 feet above Iowa Hill road bridge		[illegible]
25	do	South Yuba Water Co.'s new power canal, ¼ mile northwest of Colfax.		[illegible]
		Total flow near Colfax		[illegible]
25	do	2½ miles above Auburn		[illegible]
26	American, Middle Fork	Rubicon, 300 feet above junction with Middle Fork.		[illegible]
26	do	300 feet above junction with Rubicon		[illegible]
26	do	North Fork of, 200 feet above junction with Middle Fork.		[illegible]
26	do	Mining ditch (takes water from North Fork of Middle Fork).		[illegible]
		Total flow below junction of Middle Fork.		[illegible]
26	do	Just above mouth		[illegible]
25	American, North Fork	Below junction of North and Middle forks		[illegible]
21	do	Near Mink's place, 5 miles above mouth of South Fork.		[illegible]
26	do	North Fork canal, near Folsom		[illegible]
23	do	5 miles above mouth of South Fork, near Mink.	3.7	[illegible]
27	do	do	3.8	[illegible]
22	American, South Fork	100 feet above Riverton stone bridge		[illegible]
22	do	South Fork of Silver Creek, 300 feet above mouth.		[illegible]
22	do	Silver Creek, 150 feet above junction with South Fork of Silver Creek.		[illegible]
		Total flow below junction with South Fork.		[illegible]
23	do	Placerville ditch, 1 mile from Pacific post-office.		[illegible]
21	do	Chillie Bar Bridge, 3 miles from Placerville.		[illegible]
21	do	Big Canyon at junction with South Fork		[illegible]
21	do	At Chillie Bar		[illegible]
19	do	Natoma ditch, Natoma Vineyard Co.'s lateral.		[illegible]
19	do	Natoma ditch, Blue Ravine mine		[illegible]
21	do	Near mouth, 3 miles above Folsom		[illegible]
22	do	Natoma ditch, below dam at Salmon Falls.		[illegible]
22	do	Negro Hill canal, below dam at Salmon Falls.		[illegible]
23	do	2 miles above mouth		[illegible]
15	Mokelumne, North Fork	¼ mile above bridge, near West Point		[illegible]
15	Mokelumne, Middle Fork	150 feet below bridge, near West Point		[illegible]
16	Mokelumne, South Fork	Ditch 2 miles southeast of Fort Mountain, "Big Trees quadrangle."		[illegible]
15	do	Mokelumne ditch, ¼ mile below South Fork Bridge in flume 500 feet below head-gate.		[illegible]
Aug. 14	Mokelumne	Standard ditch flume No. 59, near Electra		[illegible]
14	do	Amador ditch, in flume 1¼ miles above Electra.		[illegible]

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Sec.-feet.*
Aug. 14	Mokelumne	500 feet above Standard Electric Co.'s power house, Electra.		51.0
14	do	From Standard power house		30.0
		Total		81.0
13	do	¼ mile below Lancha Plana dam		67.0
15	do	Campo Seco, ¼ mile below old dam		126.0
14	do	Clements at road bridge		65.0
12	do	Bridge at Woodbridge, Cal.		33.0
12	do	Woodbridge canal, 100 feet below headworks		40.0
16	do	do		29.0
16	Stanislaus, North Fork	San Antonio Creek, just below mouth of Big Trees Creek.		3.5
17	do	Old Milton (now Angels) ditch, in flume below headworks.		67.0
17	do	Below intake, Angels ditch		1.0
		Total		68.0
17	do	Mill Creek, 30 feet below junction of Love and Moran creeks.		2.0
21	Stanislaus, Middle Fork	Clarks Fork at mouth		53.0
21	do	Below mouth of Clarks Fork		126.0
21	do	Above mouth of Clarks Fork		73.0
20	Stanislaus, South Fork	Canal, Tuolumne Electric Power Co., near intake (takes all of South Fork).		54.0
20	do	Soulsby ditch, branch of Tuolumne Electric Co. canal, 50 feet above main ditch.		16.0
22	Stanislaus	Below Colliers		193.0
21	do	Abbotts Ferry		170.0
23	do	Parrotts Ferry	0.6	168.0
23	do	Robinsons Ferry		158.0
23	do	Ditch near Robinsons Ferry		12.0
		Total		170.0
May 12	do	Stanislaus Water Co. canal, Flume No. 3		129.0
Aug. 17	do	Stanislaus Water Co. canal, below intake		154.0
19	do	¼ mile below Knights Ferry		166.0
20	do	Oakdale, ¼ mile above railroad bridge		125.0
22	Tuolumne, North Fork	In flume of Goldwin Mining Co., all of water of North Fork.		6.0
30	Tuolumne	Cherry Creek, just below Lake Eleanor trail crossing.		6.0
30	do	Eleanor Creek, ¼ mile below trail crossing		4.4
31	Tuolumne, Middle Fork	Below bridge on road from Crockers to Hog ranch.		3.0
29	Tuolumne	Upper end Hetch Hetchy Valley		66.0
29	do	Rancheria Creek, head of falls, ¼ mile southeast of trail.		7.0
29	do	Till-Till Creek, just above junction Rancheria Creek.		0.5
29	do	Falls Creek, 300 feet above junction with Tuolumne.		4.0
29	do	Lower end Hetch Hetchy Valley		89.0
27	do	¼ mile above junction with South Fork		152.0
27	Tuolumne, South Fork	¼ mile above mouth		20.0
Sept. 2	Tuolumne	225 feet above falls, lower end Tuolumne Meadows.		23.0
Aug. 26	do	Wards Ferry, 300 feet below bridge		159.0

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Second-feet.*
Aug. 26	Tuolumne	Jacksonville, at cable crossing		[illegible]
25	do	Woods Creek, Jacksonville		[illegible]
27	do	Lagrange ditch and Hydraulic Mining Co. canal above Lagrange dam.		[illegible]
27	do	Turlock canal, at gate where canal leaves headworks tunnel.		[illegible]
27	do	Lagrange, 1,000 feet below bridge		[illegible]
		Total at Lagrange		[illegible]
Sept. 3	Merced	Illilouette Creek, 100 yards above junction with Merced.		[illegible]
3	do	150 feet above junction with Illilouette Creek.		[illegible]
		Total above intake, electric power tunnel, Yosemite Valley.		[illegible]
3	do	Tenaya, 50 yards above bridge, near camp, Ideal Valley.		[illegible]
4	do	Bridal Veil Creek, 50 yards below bridge		[illegible]
4	Merced, South Fork	Below buildings at Wawona		[illegible]
Aug. 30	Merced, North Fork	At junction		[illegible]
31	Merced	Bonton Mills power house, in flume		[illegible]
31	do	Horseshoe Bend, 900 feet below old suspension bridge.		[illegible]
Sept. 3	do	1 mile above Merced Falls		[illegible]
1	do	Merced Falls, 1,000 feet below dam		[illegible]
1	do	Ditch below power house, Merced Falls		[illegible]
4	do	Crocker Hoffman canal, at road bridge, 3 miles below Snelling.		[illegible]
6	San Joaquin	Granite Creek, 100 feet below sheep bridge		[illegible]
6	do	300 feet below junction with Jackass Creek		[illegible]
6	do	Jackass Creek, 50 feet above junction with San Joaquin.		[illegible]
8	do	Middle Fork, 300 feet above Miller Bridge		[illegible]
10	Mono Creek	At lowest trail crossing		[illegible]
10	San Joaquin, South Fork	Trail crossing from Mono to Pine Ridge		[illegible]
10	Big Creek	Dam site, lower end of valley, trail from Mono to Pine Ridge.		[illegible]
9	San Joaquin, North Fork	Canal, at reservoir in flume above San Joaquin power house.		[illegible]
10	San Joaquin	Below San Joaquin electric power house		[illegible]
8	do	Pollasky, north of pavilion		[illegible]
11	do	Herndon, at road bridge		[illegible]
12	do	Below dam, at Mendote		[illegible]
12	do	Miller and Lux canal, small dam intake No. 3.		[illegible]
12	do	Miller and Lux canal, at canal bridge No. 2	5.1	[illegible]
17	King	Dinkey Creek, 75 feet below old bridge, road Ockenden to Laurel Creek.		[illegible]
18	King, North Fork	100 yards above trail crossing, 1 mile from Cliff camp.		[illegible]
18	do	Bear Creek (estimated)		[illegible]
18	do	Deer Creek (estimated)		[illegible]
18	do	Blue Canyon Creek		[illegible]
18	King, Middle Fork	Crown Creek		[illegible]
20	do	300 feet below trail to Simpsons Meadows		[illegible]

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Sec.-feet.*
Sept. 22	King, South Fork	Bubbs Creek, 100 yards above junction with South Fork.		32.0
22	do	100 yards below trail, ¼ mile above junction Bubbs Creek.		29.0
		Total below mouth of Bubbs Creek		61.0
22	do	Granite Creek, 50 yards above bridge on trail crossing.		0.7
22	do	Sheep Creek, just above old hotel (estimated).		2.0
23	do	Roaring River, at trail crossing		10.0
22	King, North Fork	¼ mile above mouth		35.0
22	King	Big Creek, just above mouth		0.5
21	do	At Red Mountain gaging station	4.0	217.0
24	do	76 canal, near headworks, Trimmer Springs crossroad.		31.0
22	do	Enterprise canal, Trimmer Springs crossroad.		2.0
24	do	Church canal, Trimmer Springs crossroad.		121.0
24	do	Fowler Switch canal		0.0
24	do	Kingsburg canal, Trimmer Springs crossroad.		5.0
25	do	At bridge, 1 mile north of Reedley		74.0
26	do	Kingsburg, below wagon-road bridge		117.0
25	Kaweah, North Fork	Lower end of Davis ranch		4.0
12	Kaweah, East Fork	Mount Whitney Power Co.'s flume		18.0
27	do	¼ mile above headworks, Mount Whitney Power Co.'s flume.		15.0
27	do	200 feet below junction diversion, Mount Whitney Power Co.'s flume.		15.5
27	Kaweah, Middle Fork	Marble Fork, 100 yards above junction with Middle Fork.		4.0
28	do	100 yards below trail crossing from Soldiers Camp to Tar Gap.		11.0
27	do	100 yards above junction with Marble Fork		20.0
30	do	3 miles above Three Rivers		31.0
10	do	¼ mile above Sequoia National Park line		31.0
26	do	do		29.0
29	Kaweah, South Fork	Horse Creek at lower end of Hackett Meadow.		1.0
25	do	200 yards above bridge on road from Lemon Cove to Three Rivers.		0.7
29	do	Sequoia National Park line, Cahoon's place.		9.8
29	do	Near lower end of sand meadows		2.0
27	Kaweah	¼ mile above iron bridge		33.0
30	Tule, Middle Fork	East Mount Moses near headworks Doyle Power ditch.		2.6
30	do	Above headworks Doyle Power ditch		14.0
30	do	Trail crossing near junction East Fork		24.0
Oct. 1	Tule, East Fork	100 yards above junction with Middle Fork		15.0
		Total below junction of Middle and East forks.		39.0
3	do	Trail crossing from Nelsons to Indian Reservation.		10.0
2	Tule, South Fork	Tom Wheaton's ranch		3.0
2	do	6 miles below Indian Agency, 50 yards above crossroads.		3.0

Miscellaneous measurements in San Francisco Bay drainage basin—Continued.

Date.	Stream.	Location.	Gage height.	Discharge.
1902.			*Feet.*	*Second-feet.*
Oct. 2	Tule, North Fork	At junction with main river		[illegible]
May 15	Tule, South Fork	Near mouth		16.0
Oct. 2	do	do		[illegible]
2	Tule	McFarlands Bridge, 8 miles east of Portersville.		15.0
3	do	Pioneer canal intake		13.9
3	do	Pioneer canal, 1 mile below head gate		6.8
3	do	1 mile below intake Pioneer canal, opposite above point.		8.2
3	do	Pioneer canal, Portersville orange grove, no water used for irrigation.		3.8
4	Kern, North Fork	Little Kern, 100 yards above junction with North Fork.		[illegible]
4	do	100 yards above Little Kern		15.0
		Total		172.0
6	do	Thurston ditch, road crossing to Hot Springs.		0.5
6	do	Upper Murphy ditch, entrance to weir		7.0
6	do	Stafford & Neil ditch at old bridge back of church.		1.5
6	do	Sumner ditch, just above dairy		7.9
6	do	West channel, point diversion, Kern River Power Co.		130.0
6	do	Center channel, point diversion, Kern River Power Co.		15.0
6	do	East channel, point diversion, Kern River Power Co.		6.0
		Total		160.0
7	do	¼ mile above mouth of Salmon, between Salmon and Tobias creeks.		224.0
7	do	Salmon Creek, 50 yards above junction with Kern.		0.5
7	do	¼ mile above gaging station, Kern River Power Co.		127.0
8	do	350 yards below wagon bridge, Isabella to Kernville.		32.0
8	do	Hooper ditch at wagon bridge, Isabella to Kernville.		9.0
8	do	Stafford & Neil ditch, just above flume in gulch.		0.12
8	do	Lower Stafford ditch		0.6
8	Kern South Fork	Above junction with Kern		18.0
8	Kern, North Fork	Lower Murphy ditch, 75 yards above Weldon crossroads.		0.7
8	do	Bennett & Kelley ditch, above Weldon crossroads.		7.0
8	Kern	200 yards below junction, North and South forks.		24.0
8	do	¼ mile above power house, Kern River Power Co.		18.0
8	do	Below Clear Creek		26.0
8	do	Clear Creek at mouth		[illegible]
7	do	¼ mile below power house at mouth of canyon.		174.0
8	do	"First point of measurement"		17.0
8	do	Democrat Springs at cable Edison Electric Co.		179.0
7	do	Proposed site of Edison power house below intake of company's tunnel.		14.0

SOUTHERN CALIFORNIA DRAINAGE.

Under the head of Southern California drainage have been included data concerning the streams of that part of the State south of the San Joaquin Basin. There are thus included the Mohave, which flows from the mountains north of San Bernardino into the Mohave Desert, a portion of the Great Interior Basin, as well as those flowing toward the south or southwest, whose waters, in times of flood at least, reach the Pacific Ocean.

Arroyo Seco rises on the eastern slope of the Santa Lucia Mountains and flows east and empties into Salinas River at Soledad, Cal.

San Lorenzo Creek drains the western slopes of the Gavilan Mountains and enters Salinas River near King City, Cal. There is a reservoir and dam site 5 miles above its mouth. The flood waters are used for winter irrigation. Salinas River drains into the Pacific through Monterey Bay.

The drainage basin of San Gabriel River lies on the southern slope of the Sierra Madre, being included in Los Angeles County, Cal. The various tributaries join the river before it enters its lowest canyon, whence it appears finally on the plain in the vicinity of Azusa. The seepage waters of this valley appear lower down in the river and finally enter the Pacific Ocean not far from the mouth of Los Angeles River. All of the surplus waters of this stream are now used for irrigation purposes, and it is only an occasional flood that passes the gaging station.

Santa Ana River has its source on the southern slope of the San Bernardino Mountains and flows southerly, appearing from its canyon 4 miles north of Redlands. Its waters are completely used in San Bernardino Valley. At the lower part of the valley the water appears again in the vicinity of Rincon where the river passes through a comparatively narrow gorge, and the general direction of the stream is thence southwesterly, emptying into the Pacific Ocean.

The headwaters of Mohave River have their source on the northern slope of the Sierra Madre. It flows north, finally disappearing in the sands of the Mohave Desert.

The following is a list of the stations in the Southern California drainage:

Arroyo Seco at Pettitt's ranch, near Soledad, Monterey County, Cal.
San Lorenzo Creek near King City, Cal.
San Gabriel River and canals at Azusa, Cal.
Santa Ana River below Warmsprings, Cal.
Mohave River at Victorville, Cal.

ARROYO SECO AT PETTITT'S RANCH, NEAR SOLEDAD, MONTEREY COUNTY, CAL.

A gaging station was established by W. W. Cockins, jr., December, 1900, at Foster's ranch, near Piney post-office, California. The high water of January, 1901, enlarged an old channel, and the gaging station was removed to Pettitt's ranch, 4 miles below. The purpose of establishing these gaging stations was to get the maximum flood discharge and the amount of water available for storage. The total area

of the basin drained above Pettitt's ranch is 215 square miles. The observer is Mrs. Charles Pettitt.

Discharge measurements of Arroyo Seco at Pettitt's ranch near Soledad, Monterey County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
February 24	S. G. Bennett	8.2	1,79[illegible]
February 25	do	11.7	7,85[illegible]
February 26	do	9.0	2,77[illegible]
April 29	do	5.75	144
July 18	H. Hamlin	5.08	1[illegible]
August 7	do	4.9	[illegible]
November 14	do	5.42	[illegible]
November 15	do	5.40	3[illegible]
December 31	S. G. Bennett	5.40	4[illegible]

Daily gage height, in feet, of Arroyo Seco at Pettitt's ranch near Soledad, Monterey County, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.3	5.3	7.5	5.9	5.7	5.5	5.2	5.0	4.9	4.8	5.2	[illegible]
2	5.3	5.3	8.7	6.0	5.7	5.4	5.2	5.0	4.9	4.8	5.2	[illegible]
3	5.3	5.3	7.8	5.9	5.7	5.5	5.2	5.0	4.8	4.8	5.2	[illegible]
4	5.3	5.3	7.2	5.8	5.7	5.4	5.2	4.9	4.9	4.8	5.2	[illegible]
5	5.3	5.3	6.9	5.8	5.7	5.4	5.2	5.0	4.8	4.9	5.2	[illegible]
6	5.3	5.3	7.1	5.8	5.7	5.4	5.2	4.9	4.9	4.8	5.1	[illegible]
7	5.3	5.3	6.9	8.1	5.7	5.4	5.2	4.9	4.8	4.9	5.1	[illegible]
8	5.3	5.3	8.3	6.7	5.6	5.4	5.2	4.9	4.8	4.9	5.1	[illegible]
9	5.3	5.7	7.9	6.4	5.7	5.4	5.2	4.9	4.8	4.9	5.1	[illegible]
10	5.3	5.5	7.3	6.3	5.6	5.4	5.2	4.9	4.8	4.9	7.0	[illegible]
11	5.3	5.5	7.1	6.2	5.6	5.4	5.2	4.9	4.8	4.9	5.9	[illegible]
12	5.3	5.6	6.8	6.2	5.6	5.4	5.2	4.9	4.8	4.9	5.5	[illegible]
13	5.3	5.5	6.8	6.1	5.6	5.4	5.2	4.9	4.8	5.0	5.5	[illegible]
14	5.3	5.5	6.5	6.0	5.6	5.4	5.1	4.9	4.8	4.9	5.4	[illegible]
15	5.3	6.4	6.4	6.0	5.6	5.4	5.1	4.9	4.8	5.0	5.4	[illegible]
16	5.3	6.0	6.3	6.0	5.6	5.3	5.1	4.9	4.8	4.9	5.4	[illegible]
17	5.3	6.0	6.3	6.0	5.6	5.3	5.1	4.9	4.8	5.0	5.4	[illegible]
18	5.3	5.9	6.2	5.9	5.6	5.3	5.1	4.9	4.8	4.9	5.4	[illegible]
19	5.3	5.9	6.2	5.9	5.5	5.3	5.1	4.9	4.8	5.0	5.4	[illegible]
20	5.4	5.7	6.2	5.9	5.5	5.3	5.1	4.9	4.8	5.0	5.4	[illegible]
21	5.3	7.4	6.1	5.9	5.5	5.3	5.1	4.9	4.8	5.0	5.4	[illegible]
22	5.3	8.8	6.0	5.9	5.5	5.3	5.1	4.9	4.8	5.0	5.3	[illegible]
23	5.3	6.3	6.0	5.8	5.5	5.3	5.0	4.9	4.8	5.0	5.3	[illegible]
24	5.3	8.7	6.1	6.0	5.5	5.3	5.0	4.9	4.8	5.3	5.3	[illegible]
25	5.4	9.1	6.0	5.9	5.5	5.3	5.0	4.9	4.8	5.5	5.3	[illegible]
26	5.4	9.1	6.1	5.9	5.5	5.2	5.0	4.9	4.8	5.4	5.3	[illegible]
27	5.4	8.2	6.0	5.8	5.5	5.2	5.0	4.9	4.8	5.2	5.3	[illegible]
28	5.4	7.8	5.9	5.8	5.5	5.2	5.0	4.9	4.8	5.2	5.3	[illegible]
29	5.4	.....	5.9	5.8	5.5	5.2	5.0	4.9	4.8	5.2	5.3	[illegible]
30	5.3	.....	5.9	5.8	5.5	5.2	5.0	4.9	4.8	5.2	5.3	[illegible]
31	5.3	.....	5.9	.....	5.5	.....	5.0	4.9	.....	5.2	.....	[illegible]

Rating table for Arroyo Seco River at Pettitt's ranch near Soledad, Monterey County, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.0	7	6.8	620	8.6	2,200	10.4	5,130
5.2	15	7.0	750	8.8	2,450	10.6	5,540
5.4	40	7.2	890	9.0	2,720	10.8	5,960
5.6	75	7.4	1,030	9.2	3,010	11.0	6,380
5.8	145	7.6	1,190	9.4	3,320	11.2	6,800
6.0	230	7.8	1,360	9.6	3,650	11.4	7,220
6.2	320	8.0	1,550	9.8	4,000	11.6	7,650
6.4	410	8.2	1,750	10.0	4,360	11.8	8,090
6.6	510	8.4	1,970	10.2	4,740	12.0	8,530

Estimated monthly discharge of Arroyo Seco at Pettitt's ranch near Soledad, Monterey County, Cal.

[Drainage area, 215 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	40	25	28	1,722	0.13	0.15
February	2,860	25	605	33,600	2.81	2.93
March	2,320	185	620	38,122	2.88	3.32
April	1,650	145	270	16,066	1.26	1.41
May	105	55	74	4,550	.34	.39
June	55	15	32	1,904	.15	.17
July	15	7	12	738	.06	.07
August	7	3	4	246	.02	.02
September	3	0	0	0	.00	.00
October	55	0	9	553	.04	.05
November	750	11	57	3,392	.27	.30
December	145	25	54	3,320	.25	.29
The year	2,860	0	147	104,213	.68	9.10

SAN LORENZO CREEK NEAR KING CITY, CAL.

A gaging station was established December 16, 1900, at Hollenbeck's ranch. To obtain a reliable observer it was necessary to move the gaging station to the Mathews dam site one-half mile above the Hollenbeck ranch on November, 1901. The stream is very flashy, and the rating curve for 1902 was completed by taking the cross section and slope with a level and calculating the discharge by the Kutters formula. The observer is J. L. Mathews.

Discharge measurements of San Lorenzo Creek near King City, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
January 24	S. G. Bennett	0.9	[illegible]
February 24	do	1.09	[illegible]
April 30	do	.09	[illegible]
July 16	H. Hamlin		[illegible]
November 12	do	.85	[illegible]

Daily gage height, in feet, of San Lorenzo Creek near King City, Cal.

Day.	Jan.	Feb.	Mar.	Apr.	Oct.	Nov.	Dec.
1902.							
1	0.9	0.9	1.1	0.9		1.0	[illegible]
2	.9	.9	3.0	.9		1.0	[illegible]
3	.9	.9	2.2	.9		1.0	[illegible]
4	.9	.9	1.4	.9		1.0	[illegible]
5	.9	.9	1.2	.9		1.0	[illegible]
6	.9	.9	1.6	.9		1.0	[illegible]
7	.9	.9	1.6	.9		1.0	[illegible]
8	.9	.9	1.8	.9		1.0	[illegible]
9	.9	.9	1.8	.9		1.0	[illegible]
10	.9	.9	1.6	.9		1.0	[illegible]
11	.9	.9	1.2	.9		1.8	[illegible]
12	.9	.9	1.2	.9		1.7	[illegible]
13	.9	.9	1.1	.9		1.6	[illegible]
14	.9	.9	1.0	.9		1.6	[illegible]
15	.9	.9	1.0	.9		1.6	[illegible]
16	.9	.9	1.0	.9		1.6	[illegible]
17	.9	.9	1.0	.8		1.6	[illegible]
18	.9	.9	1.0	.8		1.5	[illegible]
19	.9	.9	1.0	.8	0.9	1.8	[illegible]
20	.9	.9	1.0	.8	.9	1.7	[illegible]
21	.9	.9	.9	.8	1.0	1.6	[illegible]
22	.9	1.7	.9	.8	1.0	1.6	
23	.9	1.6	.9	.8	1.0	1.4	[illegible]
24	1.0	1.7	.9	.8	1.0	1.4	[illegible]
25	1.0	2.9	1.0	.8	1.0	1.4	[illegible]
26	.9	2.3	1.0	.8	1.0	1.4	[illegible]
27	.9	1.5	.9	.9	1.0	1.4	[illegible]
28	.9	1.2	.9	.9	1.0	1.4	[illegible]
29	.9		.9	.9	1.0	1.2	[illegible]
30	.9		.9	.9	1.0	1.2	[illegible]
31	.9		.9		1.0		[illegible]

Rating table for San Lorenzo Creek near King City, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	3	1.4	88	2.0	274	2.6	585
.9	5	1.5	110	2.1	317	2.7	650
1.0	15	1.6	135	2.2	364	2.8	720
1.1	32	1.7	166	2.3	415	2.9	795
1.2	50	1.8	200	2.4	470	3.0	875
1.3	68	1.9	236	2.5	525		

Estimated monthly discharge of San Lorenzo Creek near King City, Cal.

[Drainage area, 235 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	15	5	6	369	0.03	0.03
February	795	5	69	3,832	.29	.30
March	875	5	81	4,980	.34	.39
April	5	3	4	238	.02	.02
October 19–31	----------	----------	15	357	.06	.03
November	200	15	85	5,057	.36	.40
December	15	5	7	430	.03	.03

SAN GABRIEL RIVER AND CANALS AT AZUSA, CAL.

Owing to the numerous diversions it has been difficult to obtain accurate discharge measurements at Azusa; but during 1898 the San Gabriel Electric Company completed its system, and measurements are now obtained with greater ease and hence with greater accuracy. The headworks of this company are located about 6 miles above the mouth of the canyon; the water is carried along the left side by a series of tunnels and conduits, and a head of 400 feet is obtained where the electric power is generated. Weirs are placed on the conduit of the electric company, and the water is measured at this point. The capacity of the conduit is 90 second-feet.

The total flow of the river is obtained by adding the daily discharge for the river to the figures for the corresponding dates for the canals. The observer is H. F. Parkinson.

Discharge measurements of San Gabriel River at Azusa, Cal.

Date.	Hydographer.	Gage height.	Discharge.	Remarks.
1902.		*Feet.*	*Second-feet.*	
April 8	S. G. Bennett	1.4	26.0	
			34.0	Over weirs San Gabriel Power Company Canal.
			11.0	Waste gate San Gabriel Power Company.
			71.0	Total flow of San Gabriel River.
June 12	do		25.7	Flow over weirs of San Gabriel Power Company=total flow of river.
September 1	W. B. Clapp		5.0	Do.

Daily gage height, in feet, of San Gabriel River at Azusa, Cal.

Day.	Feb.	Mar.	Apr.	Nov.	Day.	Feb.	Mar.	Apr.	Nov.
1902.					1902.				
1	(a)	0.85	1.10		17		1.00	0.00	
2		3.00	1.50		18		.93	0.00	
3		1.90	1.10		19		1.25	0.00	
4		1.55	1.05		20		1.05	0.00	
5		1.40	1.02		21		.90	1.05	
6		1.57	1.00		22		.80	0.80	
7		1.20	1.20		23		.90	0.00	
8		1.20	1.20		24		1.65	0.00	
9		2.30	1.15		25		1.40	0.00	
10		1.95	1.10		26	1.75	1.30	0.00	
11		1.70	1.05	1.20	27	1.35	1.15	0.00	
12		1.50	1.00	(a)	28	1.05	1.10	0.00	
13		1.40	1.00		29		1.05	0.00	
14		1.30	0.95		30		1.20	0.00	
15		1.20	0.00		31		1.10		
16		1.10	0.00						

[a] River dry January 1 to February 25, May 1 to November 10, and November 12 to December 31.

Daily discharge, in second-feet, of San Gabriel canals at Azusa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	25	30	58	62	48	30	16	7	5	6	9	16
2	25	30	60	62	48	28	16	7	5	6	8	16
3	25	30	60	62	48	26	16	8	5	6	8	16
4	25	30	60	62	47	26	17	7	5	6	8	16
5	25	30	61	62	46	25	17	8	5	6	8	17
6	25	29	62	62	46	23	16	8	5	6	8	17
7	25	29	62	62	46	21	16	7	5	6	8	18
8	25	29	62	62	45	20	14	7	4	6	9	18
9	25	29	62	62	43	20	12	8	5	6	9	24
10	25	29	62	62	43	22	12	8	5	6	9	30
11	25	29	62	62	43	25	11	8	5	7	62	36
12	24	29	62	62	42	25	10	8	5	8	43	32
13	24	28	62	46	40	22	10	8	5	8	25	28
14	24	28	62	62	44	22	10	8	5	8	23	26
15	24	28	62	62	42	21	10	8	5	6	23	25
16	24	28	62	62	40	20	10	8	6	6	23	25
17	24	28	62	62	40	20	10	8	6	6	22	46
18	27	28	62	60	37	19	10	8	6	6	22	68
19	30	27	62	61	37	18	10	8	6	6	22	61
20	28	27	62	61	37	16	8	8	6	7	22	55
21	26	32	62	62	37	16	8	7	6	7	21	48
22	26	38	62	62	36	16	8	6	6	8	20	42
23	26	34	62	60	35	14	8	6	6	9	20	35
24	51	35	62	60	34	14	8	7	6	10	20	35
25	42	40	62	56	34	14	8	6	6	10	20	35
26	32	63	62	54	34	14	9	6	6	9	20	35
27	32	62	62	52	32	14	10	6	6	8	20	35
28	32	62	62	50	30	15	10	6	6	8	20	34
29	32	------	62	48	30	15	10	6	6	8	19	33
30	31	------	55	48	30	14	9	6	6	8	17	32
31	30	------	62	------	30	------	8	6	------	8	------	31

Rating table for San Gabriel River at Azusa, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.8	4	1.5	37	2.2	128	2.9	288
.9	7	1.6	44	2.3	147	3.0	318
1.0	10	1.7	52	2.4	167	3.1	350
1.1	13	1.8	63	2.5	188	3.2	384
1.2	18	1.9	77	2.6	210		
1.3	24	2.0	93	2.7	234		
1.4	30	2.1	110	2.8	260		

Estimated monthly discharge of San Gabriel River at Azusa, Cal.

[Drainage area, 222 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	0	0	0	[illegible]
February	57	0	3	16[illegible]
March	318	4	38	2,[illegible]
April	37	0	7	41[illegible]
May	0	0	0	[illegible]
June	0	0	0	[illegible]
July	0	0	0	[illegible]
August	0	0	0	[illegible]
September	0	0	0	[illegible]
October	0	0	0	[illegible]
November	18	0	0	[illegible]
December	0	0	0	[illegible]
The year	318	0	4	2,[illegible]

Estimated monthly discharge of San Gabriel canals at Azusa, Cal.

[Drainage area 222 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1902.				
January	51	24	28	1,7[illegible]
February	63	27	34	1,[illegible]
March	62	55	61	3,7[illegible]
April	62	46	59	3,5[illegible]
May	48	30	39	2,[illegible]
June	30	14	20	1,1[illegible]
July	17	8	11	67[illegible]
August	8	6	7	4[illegible]
September	6	4	5	[illegible]
October	10	6	7	[illegible]
November	62	8	19	1,1[illegible]
December	68	16	32	1,9[illegible]
The year	68	4	27	19,3[illegible]

Estimated monthly discharge of San Gabriel River and canals at Azusa, Cal.

[Drainage area 222 square miles.]

Month	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	51	24	28	1,722	0.13	0.15
February	120	38	37	2,055	.17	.18
March	378	63	99	6,088	.45	.52
April	99	48	66	3,928	.30	.33
May	48	30	39	2,398	.18	.21
June	30	14	20	1,190	.09	.10
July	17	8	11	676	.05	.06
August	8	6	7	430	.03	.03
September	6	4	5	298	.02	.02
October	10	6	7	430	.03	.03
November	80	8	19	1,131	.09	.10
December	68	16	32	1,968	.14	.16
The year	378	4	31	22,314	.14	1.89

SANTA ANA RIVER BELOW WARMSPRINGS, CAL.

This station, established June, 1896, is located 5 miles northeast of Mentone, Cal., three-fourths of a mile below the head works of the Santa Ana canal and opposite the warm springs in the canyon. The gage is an inclined timber fastened to a large bowlder and posts set in the bank of the river. The observer is A. Larrd.

Owing to the shifting nature of the stream bed it has not been possible to construct perfectly satisfactory rating curves, but the tables as presented are based on the best information that could be obtained. The record is not considered absolutely correct, but is given as an approximation. This river is one of the most difficult streams in the State of which to obtain an accurate record. The Edison Electric Company diverts the greater portion of the water of Santa Ana River above the gaging station, but also returns all of it above the station. They, however, allow only limited portions of the water to pass out of their conduits during certain hours of the day, holding back the water for the purpose of obtaining additional power when the greatest demand exists. The Santa Ana canal, as mentioned above, also diverts water from Santa Ana River above the station, all of which is returned to the channel of the stream after passing the point of measurement.

During the greater part of the year the canals at the mouth of the canyon divert all of the water. At such times the discharge of Santa Ana River was obtained by observations on weirs at the head works of Green Spot pipe line, Highlands canal, and Redlands canal. The water entering Redlands canal from the Redlands tunnel and Morton Canyon was assumed to offset the loss by evaporation and seepage between the old gaging station and the mouth of the canyon.

Discharge measurements of Santa Ana River and canal at Warmsprings, Cal.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1902.		*Feet.*	*Second-feet.*	
April 5	S. G. Bennett	1.39	51	River.
		-------	4	Santa Ana Canal.
		-------	55	Total discharge from drainage basin.
May 31	do	.91	8	River.
		-------	21	Santa Ana Canal.
		-------	29	Total flow.
July 10	do	.84	5	River.
		-------	18	Santa Ana Canal.
		-------	23	Total.
September 3	W. B. Clapp	.95	10	River.
		-------	14	Santa Ana Canal.
		-------	24	Total.
November 5	S. G. Bennett	.87	5	River.
		-------	13	Santa Ana Canal.
		-------	18	Total.

Daily gage height, in feet, and discharge, in second-feet, of Santa Ana River and canal [a] *at Warmsprings, Cal.*

Day.	Jan.		Feb.		Mar.		Apr.		May.		June.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1902.												
1	.....	20	.....	20	1.50	63	1.35	42	.....	45	.....	32
2	.....	22	.....	24	2.80	485	1.40	48	.....	44	.....	30
3	.....	24	.....	22	1.60	80	1.40	48	.....	43	.....	29
4	.....	23	.....	25	1.50	63	1.40	48	.....	43	.....	30
5	.....	23	.....	27	1.50	63	1.45	56	.....	42	.....	27
6	.....	23	.....	28	1.25	31	1.33	40	.....	40	.....	29
7	.....	21	.....	27	1.45	56	1.35	42	.....	39	.....	26
8	.....	23	.....	27	1.36	43	1.38	46	.....	40	.....	26
9	.....	23	.....	27	2.03	187	1.30	36	.....	38	.....	26
10	.....	22	.....	27	1.70	102	1.30	36	.....	38	.....	32
11	.....	23	.....	28	1.55	72	1.27	33	.....	37	.....	34
12	.....	23	.....	28	1.55	72	1.27	33	.....	34	.....	40
13	.....	23	.....	28	1.55	72	1.25	31	.....	34	.....	39
14	.....	23	.....	27	1.55	72	1.24	30	.....	38	.....	39
15	.....	23	.....	28	1.35	42	1.24	30	.....	34	.....	47
16	.....	23	.....	28	1.23	29	1.24	30	.....	35	.....	45
17	.....	23	.....	28	1.25	31	1.23	29	.....	35	.....	45
18	.....	23	.....	28	1.25	31	1.23	29	.....	35	.....	45
19	.....	23	.....	27	1.30	36	1.24	30	.....	35	.....	44
20	.....	24	.....	26	1.25	31	1.25	31	.....	33	.....	29
21	.....	22	.....	26	1.22	28	1.45	56	.....	33	.....	27
22	.....	24	.....	32	1.25	31	1.30	36	.....	32	.....	27
23	.....	24	.....	33	1.30	36	1.31	37	.....	33	.....	26
24	.....	45	.....	30	1.40	48	.....	54	.....	33	.....	39
25	.....	41	.....	33	1.45	56	.....	49	.....	32	.....	35
26	.....	28	2.20	240	1.50	63	.....	47	.....	34	.....	30
27	.....	25	1.60	80	1.55	72	.....	46	.....	31	.....	32
28	.....	26	1.50	63	1.53	68	.....	43	.....	31	.....	31
29	.....	25	.....	.....	1.53	68	.....	46	.....	31	.....	28
30	.....	21	.....	.....	1.50	63	.....	44	.....	31	.....	28
31	.....	21	.....	.....	1.45	56	.....	.....	.....	31	.....	.....

[a] Discharge of river was obtained by measurements over weirs on days when gage heights are not given.

Daily gage height, in feet, and discharge, in second-feet, of Santa Ana River canal at Warmsprings, Cal.—Continued.

Day.	July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1902.												
1		24		24		23		31		43		
2		32		24		25		30		23		
3		31		25		26		31		23		
4		31		25		29		33		22		
5		23		25		26		37		20		
6		23		25		24		36		19		
7		23		26		23		34		20		
8		25		28		23		37		20		
9		25		30		23		42		20		
10		25		29		24		43		20		
11		23		28		25		44		31		
12		26		28		23		42		26		
13		26		28		28		36		23		
14		27		25		27		36		23		
15		26		25		24		35		23		
16		24		25		23		33		23		
17		24		25		24		32		19		
18		25		25		24		32		20		
19		24		24		25		34		31		
20		24		23		26		36		25		
21		24		22		26		40		23		
22		24		22		24		39		24		
23		25		22		23		49		24		
24		25		22		23		51		21		
25		28		23		22		55		23		
26		26		25		22		27		26		
27		25		22		23		49		26		
28		30		25		23		50		26		
29		30		26		25		47		26		
30		27		27		27		49		26		
31		26		26				52				

[a] Discharge of river was obtained by measurements over weirs on days when gage heights are not given.

Daily mean discharge, in second-feet, of Santa Ana canal[a] below Warmsprings, Cal.

Day.	Feb.	Mar.	Apr.	Day.	Feb.	Mar.	Apr.	Day.	Feb.	Mar.	Apr.
1902.				1902.				1902.			
1		12	11	12		0	15	23		14	
2		0	15	13		13	15	24		0	
3		0	15	14		15	15	25		0	
4		0	15	15		15	15	26	0	0	
5		12	15	16		13	15	27	0	0	
6		11	15	17		14	14	28	0	0	
7		0	15	18		14	14	29		0	
8		0	15	19		14	13	30		0	
9		0	15	20		14	13	31			
10		0	15	21		13	13				
11		0	15	22		14	13				

[a] On days not given in above table there was no discharge.

Rating table for Santa Ana River below Warmsprings, Cal., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	12	1.6	80	2.2	240	2.8	485
1.1	18	1.7	102	2.3	277	2.9	540
1.2	26	1.8	125	2.4	315	3.0	600
1.3	36	1.9	150	2.5	355		
1.4	48	2.0	178	2.6	395		
1.5	63	2.1	208	2.7	440		

Estimated monthly discharge at Santa Ana River and canal below Warmsprings, Cal.

[Drainage area, 182 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	45	20	24	1,476	0.13	0.15
February	240	20	38	2,110	.21	.22
March	485	41	79	4,858	.43	.50
April	71	43	51	3,035	.28	.31
May	45	31	36	2,214	.20	.23
June	47	23	33	1,964	.18	.20
July	32	23	26	1,599	.14	.16
August	30	22	25	1,537	.14	.16
September	29	22	24	1,428	.13	.15
October	55	30	39	2,398	.21	.24
November	43	19	24	1,428	.13	.15
December	27	19	22	1,353	.12	.14
The year	485	19	35	25,400	.19	2.61

The above discharges include the discharges given in a separate table of Santa Ana Canal.

MOHAVE RIVER AT VICTORVILLE, CAL.

At Victorville, a station on the Atchison, Topeka and Santa Fe Railroad, the river passes through a narrow gorge, locally known as The Narrows. This place has been under investigation as a possible dam site, and soundings for the depth of bed rock were made by the United States Geological Survey during the season of 1899. The greatest depth of bed rock was found to be 54 feet. The diamond

drill showed the rock to be a fine granite. A more detailed account of this exploration will be found in the Twenty-first Annual Report, Part IV. Above The Narrows the valley broadens into a large reservoir site, but as no surveys of it have been made the capacity is unknown. In order to determine the amount of water available for storage for this reservoir a gaging station was established February 27, 1899.

During 1902 no flood passed the gaging station. The channel is in sand, which is constantly shifting. The rod readings are of little value during low stages. Between January 1, 1902, and May 3, 1902, the discharge varied from 47 to 67 cubic feet per second, though the gage reading was 0.9 for the entire time. At the latter date the rod readings were discontinued.

The mean estimated discharge for each month was obtained by averaging the discharge as obtained by meter measurements made during the month.

Discharge measurements of Mohave River at Victorville, Cal.

Date.	Hydrographer.	Gage height.	Discharge
1902.		*Feet.*	*Sec.-feet.*
January 4	P. H. Leahy	0.9	47
January 21	do	.9	5[illegible]
February 1	do	.9	5[illegible]
February 25	do	.9	6[illegible]
March 5	do	.9	6[illegible]
March 29	do	.9	6[illegible]
April 5	do	.9	67
April 19	do	.9	6[illegible]
April 26	do	.9	47
May 10	do	.9	37
May 25	do		49
June 8	do		5[illegible]
June 27	do		47
July 5	do		3[illegible]
July 26	do		41
August 9	do		4[illegible]
August 15	do		3[illegible]
October 20	do		49
October 30	do		45
November 10	do		4[illegible]
November 27	do		50
December 11	do		6[illegible]
December 19	do		6[illegible]
December 27	S. G. Bennett		55

Estimated monthly discharge of Mohave River at Victorville, Cal.

[Drainage area, 400 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	53	47	50	3,074	0.13	0.15
February	63	58	60	3,332	.15	.16
March	66	66	66	4,058	.17	.20
April	67	47	59	3,512	.15	.17
May	49	37	43	2,644	.11	.13
June	53	47	50	2,975	.13	.15
July	41	38	40	2,460	.10	.12
August	48	33	40	2,460	.10	.12
September [a]			44	2,618	.11	.12
October	49	45	47	2,890	.12	.14
November	50	43	46	2,737	.12	.13
December	69	55	64	3,808	.16	.18
The year	69	33	51	36,568	.13	1.77

[a] Estimated.

MISCELLANEOUS MEASUREMENTS IN SOUTHERN CALIFORNIA DRAINAGE.

Ventura River.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
		Feet.	*Sec.-feet.*	
September 25	J. B. Lippincott		2.0	Matilija, above mouth of North Fork.
September 25	do		5.23	Below diversion of Ventura City water system, Cayote Creek.
September 26	do		1.5	Power ditch near head.

Ventura River, North Fork.

September 25	J. B. Lippincott		0.33	In flume.

San Gabriel River.

September 1	W. B. Clapp		0.9	Slauson well.
July 15	J. B. Lippincott		16.5	Banta ditch, near head.
July 15	do		10.6	Cate ditch.
July 15	do		19.1	Standifer ditch.
July 15	do		23.8	San Gabriel River (Rio Hondo), Old Mission Bridge.

Santa Ana River.

SAN ANTONIO CREEK.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1902.		*Feet.*	*Sec.-feet.*	
June 28	J. B. Lippincott		0.55	Water passing San Gabriel Power Co.'s powerhouse in creek.
July 12, 12.33 p. m.	do		.47	Do.
August 2, 12.10 p. m	do		.40	Do.
August 9, 12.11 p. m	do		.40	Do.
August 29, 12.40 p. m	do		.85	Do.
September 27, 12 m	do		.36	Do.
October 18, 12 m	do		.39	Do.
June 28	do		7.40	Concrete weir basin. San Gabriel Electric Co.'s power house.
July 12, 12.20 p. m	do		6.10	Do.
August 2, 12 m	do		5.59	Do.
August 9, 11.48 a. m	do		5.67	Do.
August 29, 12.30 p. m	do		4.59	Do.
September 27, 11.37 a. m	do		4.64	Do.
October 18, 11.38 a. m	do		4.31	Do.
June 28	do		.34	Fountain of Life Spring weir.
July 12, 12.15 p. m	do		.34	Do.
August 2, 12.05 p. m	do		.30	Do.
August 9, 11.42 a. m	do		.32	Do.
August 29, 12.20 p. m	do		.29	Do.
September 27, 11.33 a. m	do		.29	Do.
October 18, 12 m	do		.30	Do.
August 2	do		6.31	Spring Hill weir.
August 9, 11.22 a. m	do		6.36	Do.
August 9, 1 p. m	do		5.88	Do.
August 29, 12.07 p. m	do		5.59	Do.
August 29, 12.10 p. m	do		5.40	Do.
September 27, 12.05 p. m	do		5.28	Do.
October 18, 12.12 p. m	do		5.01	Do.
June 28	do		7.69	Baby Ruth weir.
July 12, 11.40 a. m	do		6.88	Do.
July 12, 1.13 p. m	do		6.58	Do.
August 2, 11.15 a. m	do		6.15	Do.
August 9, 11 a. m	do		6.15	Do.
August 9, 1.12 p. m	do		5.99	Do.
August 29, 11.45 a. m	do		5.61	Do.
September 29, 12.30 p. m	do		4.88	Do.
October 18, 12.30 p. m	do		4.74	Do.
April 3	S. G. Bennett		11.4	Division weir.
June 28	J. B. Lippincott		6.98	Do.
July 12, 10.58 a. m	do		6.11	Do.
July 12, 2.40 p. m	do		5.55	Do.
August 2, 10.30 a. m	do		5.19	Do.
August 2, 2.30 p. m	do		4.71	Do.
August 9, 10.18 a. m	do		5.31	Do.
August 9, 2.40 p. m	do		4.53	Do.
August 29, 10.55 a. m	do		4.64	Do.
August 29, 2.27 p. m	do		3.98	Do.
September 27, 10.30 a. m	do		4.33	Do.
September 27, 2.15 p. m	do		3.90	Do.
October 18, 10.55 a. m	do		4.36	Do.

Santa Ana River—Continued.

SAN ANTONIO CREEK—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1902.		*Feet.*	*Sec.-feet.*	
June 28	J. B. Lippincott		1.38	San Antonio tunnel.
July 12	do		1.27	Do.
August 2	do		1.19	Do.
August 9	do		1.17	Do.
August 30	do		1.15	Do.
September 27	do		1.12	Do.
CUCAMONGA CREEK.				
April 3	S. G. Bennett		5.0	Above headworks, Iamosa Water Co.
LYTLE CREEK.				
April 4	S. G. Bennett		20.0	Above intake, Rialto canal.
September 5	W. B. Clapp		5.0	Weir headworks, Rialto canal.
WEST TWIN CREEK.				
April 4	S. G. Bennett		3.2	Mouth of canyon.
September 3	W. B. Clapp		.13	Do.
EAST TWIN CREEK.				
April 4	S. G. Bennett		5.0	Total flow.
September 4	do		.4	Do.
CITY CREEK.				
April 7	S. G. Bennett		12.6	Total flow.
September 4	W. B. Clapp		.19	Do.
PLUNGE CREEK.				
April 7	S. G. Bennett		12.4	Total flow.
September 4	W. B. Clapp		.37	Do.
HIGHLANDS CANAL.				
May 31	S. G. Bennett		7.9	Cippoletti weir at headworks.
July 10	do		11.5	Do.
September 3	W. B. Clapp		11.1	Do.
November 5	S. G. Bennett		10.0	Do.
REDLANDS CANAL.				
May 31	S. G. Bennett		19.6	Sand box weir.
July 10	do		10.6	Do.
September 3	W. B. Clapp		14.6	Do.
November 5	S. G. Bennett		7.6	Do.
REDLANDS TUNNEL.				
July 10	S. G. Bennett		0.9	Weir.

Santa Ana River—Continued.

MILL CREEK.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1902.		*Feet.*	*Sec.-feet.*	
April 5	S. G. Bennett		11.0	Old zanja.
			5.0	Wash.
			5.0	Crafton canal.
			21.0	Total.
May 31	S. G. Bennett		19.0	Total flow.
July 10	do		10.8	Crafton weir, total flow.
September 3	W. B. Clapp		5.3	Total flow.
November 5	S. G. Bennett		12.3	Old zanja, total flow.

Return water to Santa Ana River, natural flow in second-feet, compared with developed water in San Bernardino Valley, above Colton.

[Measurements by K. Sanborn.]

Date.	Location.	Discharge.		
		Developed.	Natural.	Total.
1902.				
September 30	Hawes & Talmage ditch		0.00	0.00
September 30	Rabel dam		0.00	0.00
September 30	Shay or Stout dam		0.00	0.00
September 30	McKinzie		0.00	0.00
October 13	Beam		0.22	0.22
September 30	Riverside Water Co.'s upper canal	26.08	21.89	47.97
October 7	Gage canal, intake Santa Ana River		0.00	0.00
October 11	Gage canal, flume over road Redlands Pass	30.17		30.17
October 13	Logsdon & Farrell		0.00	0.00
October 13	Whitlock		0.00	0.00
October 13	Daley		0.00	0.00
October 7	McIntyre		0.00	0.00
October 13	Whiting		0.00	0.00
October 14	Swamp		0.93	0.93
October 7	Ranchero & Bloomington	2.28		2.28
October 14	Ward & Warren	0.30	1.58	1.88
September 30	Mill flume, Riverside Water Co		0.50	0.50
September 30	Mill pump, Riverside Water Co	1.20		1.20
October 7	Camp Carlton	1.70		1.70
October 7	Colton Terrace Water Co	1.08		1.08
October 7	City of Colton pumping plant	3.53		3.53
September 30	Meeks & Daley ditch		13.40	13.40
September 29	West Riverside 350-inch pumping plant	5.94		5.94
October 11	Rogers pumping plant	4.38		4.38
October 11	Santa Ana River flume, Riverside pumping plant No. 1	2.95		2.95
October 11	Santa Ana River flume, Riverside pumping plant No. 2	2.08		2.08
	Total	81.69	38.52	120.21

NOTE.—The West Riverside flume carries the water pumped by the West Riverside 350-inch plant, a portion of the water pumped by the Rogers pumping plant, and also a portion of the Meeks & Daley water; for these reasons it is not included under a special heading.

The Gage canal, Palm Avenue weir, and Bloomington flume torn out, Bloomington water running in the Ranchero ditch.

East Riverside Irrigation District or the Riverside Highland Water Co. running 2.7 second-feet over weir in tunnel, and pumping direct into the main pipe below end of tunnel, one pumping plant not running.

Return waters in San Bernardino Valley below Slover Mountain and above Riverside Narrows, Santa Ana.

[K. Sanborn, hydrographer.]

Date.	Location.	Discharge.
		Sec.-feet.
September 3	Santa Ana River, at Rincon wagon bridge	[a]75.00
September 29	Riverside Water Co. flume, at head of lower canal	3.07
September 29	Rubidoux canal	7.19
September 29	Evans ditch, at north line, Riverside canal	2.17
September 29	Evans ditch, 1 mile south of Riverside canal line	0.53
September 29	Evans Island ditch, at west end of West Riverside bridge	5.35
September 29	Alvetriz ditch, at east end of West Riverside bridge	1.96
October 10	Santa Ana River, at Riverside Narrows	43.25
	Total	63.52

[a] W. B. Clapp.

COLUMBIA RIVER DRAINAGE BASIN.

Next to the Colorado, Columbia River is the largest river in the arid region, its drainage basin including parts of Washington, Oregon, Idaho, and Montana and a large area in Canada. The Columbia and its numerous tributaries are of great importance, offering good sites for water-power development and an abundance of water for irrigation, while the main river is navigable for a considerable distance.

A great part of the water of Columbia River and its tributaries flows to waste, not being utilized. This is due to the fact that the river has cut so deeply into the lava-covered plains that water can not be diverted except at points near the mountains, where the streams are of small size and have not yet entered the deeply incised canyon in the plateaus. The following rivers are tributary to the Columbia:

Umatilla River rises in the well-wooded country in northeastern Oregon and flows in a general westerly direction, entering Columbia River below the mouth of Wallawalla River. The country north of Umatilla is high and rolling. A number of canals divert water from the lower course of the stream to irrigate lands on either side.

Yakima River has its source in Keechelus Lake, on the eastern slope of the Cascade Mountains, in Kittitas County, Wash. Within a short distance it receives the waters of Kachess Lake, and 2½ miles above Clealum it receives the outlet of the last of the three large headwater lakes. It enters Columbia River 23 miles below Kiona, Wash.

Naches River has its source on the eastern slope of the Cascade Mountains, in Yakima County, Wash. It flows in a general southeasterly direction, entering Yakima River a short distance above North Yakima. Irrigation is practiced in the narrow valley along the lower course of the river, but its waters are of greater value for the irrigation of lands west of North Yakima. The river has considerable

fall and the water can easily be diverted by means of comparatively short canals. For this reason it is of more value for irrigation purposes than Yakima River, which has less fall.

Tieton River is the principal tributary of the Naches River and discharges into the latter about 17 miles above its junction with Yakima River, near North Yakima. Its source is in the Cascade Mountains in the vicinity of Cowlitz Pass. A peculiar feature of the stream is the turbid, milk-white appearance of the water, it being similar in this respect to White River, on the western slope of the Cascade Range. The water of the South Fork of the Tieton, 25 miles above the mouth, is however, perfectly clear. The forks head in the glaciers of a peak of the Cascades known locally as Goat Rock.

Spokane River rises in the northern part of Idaho, being the outlet of Lake Coeur d'Alene. It passes into Washington, flows in a northerly direction, and enters Columbia River near latitude 47° 52′ north. It is about 120 miles long.

Missoula River has its source in Silverbow County, Mont., and flows northerly until it receives the waters of Little Blackfoot River, when it takes a more northwesterly course. The name Missoula is usually applied to that portion of the river between the junction of Blackfoot and Hellgate rivers and the mouth of Pend Oreille River. From that point to its junction with Columbia River it is called Clark Fork of Columbia.

The source of Bitterroot River is in the high mountains which form the boundary line between Montana and Idaho. It flows in a northerly direction, entering Missoula River a short distance below the city of Missoula. The tributaries on the east side drain comparatively low hills and contribute little to the supply of the river. The west side branches, on the contrary, are numerous, draining a precipitous and heavily wooded area. Their discharges are regulated by many small lakes fed by banks of snow, which continue far into the summer before disappearing altogether. From Hamilton to Missoula, a distance of 48 miles, the fall of the river is 350 feet, or 7.3 feet to the mile.

Snake River, which is the largest affluent of the Columbia, rises on the southern slope of the Continental Divide in the Yellowstone National Park, draining the country west and southwest of Yellowstone Lake. From Shoshone, Lewes, and Hart Lakes, near its head, the river flows in a southerly direction through a timbered and mountainous country, resulting in a long period of high water. After continuing through this area for about 20 miles it broadens into Jackson Lake, a deep body of water about 3 miles wide and 8 miles long. Below the lake the river flows through Jackson Hole Valley—about 40 miles long and 8 miles wide—and then enters a long canyon near the Idaho-Wyoming line. All of the large tributaries come from the east, receiving their waters from the Wind River Range. The west side of the valley is bounded by the high Teton Mountains, from which

most of the drainage flows westward through Tieton River into North Fork of Snake River. It empties into Columbia River near Pasco Junction, in the State of Washington.

The headwater tributaries of Palouse River have their sources in western Idaho. After passing into Washington the streams unite to form Palouse River, which has a general southwesterly course, through a rolling country. Six miles below Hooper, Wash., the river bends suddenly to the south and enters its canyon, through which it flows until its junction with Snake River. A short distance above the mouth of the river are the Palouse Falls, approximately 130 feet high.

Weiser River drains Washington County, in the extreme western part of Idaho, and flows into Snake River at Weiser, Idaho.

The Boise drains a mountainous and well-wooded country in Elmore County, Idaho. The effects of the forests are shown in the high flow that is maintained throughout the summer season, in contrast to the discharge of Weiser River, farther to the west, which drains a more barren country. Below the gaging station, which is located in the canyon, a large number of canals divert water to irrigate lands in Boise Valley. The diversion of the water is now so great that frequent complaints of scarcity are heard.

Bruneau River rises in northern Nevada and flows in a general northerly course through southern Idaho, emptying into Snake River at a point about south of Boise. Fall River is one of the small tributaries of the Snake River at its headwaters in eastern Idaho. The following list includes the stations in the Columbia River drainage basin:

Umatilla River at Gibbon, Oreg.
Yakima River at Kiona, Wash.
Yakima River at Union Gap, Wash.
Naches River near North Yakima, Wash.
Tieton River near North Yakima, Wash.
Spokane River at Spokane, Wash.
Missoula River at Missoula, Mont.
Bitterroot River near Grantsdale, Mont.
Palouse River near Hooper, Wash.
Weiser River near Weiser, Idaho.
Boise River near Boise, Idaho.
Bruneau River near Grandview, Idaho.
Snake River at Montgomery Ferry, near Minidoka, Idaho.
Snake River (North Fork) near Ora, Idaho.
Fall River near Marysville, Idaho.

UMATILLA RIVER AT GIBBON, OREG.

The station at Gibbon, Oreg., was established July 22, 1896, and is located one-half mile west of the railroad station. The gage rod, which was located one-quarter of a mile below the railroad station, was carried away by a freshet in May, but the bench mark, a cross in black paint on the highest point of the rock to which the rod was fastened, still remains. It is 4.40 feet above datum. The same flood also carried away the entire equipment, consisting of a five-eighth-inch

cable with car, supports, tag, and stay wires. These were all renewed on September 10, 1902. The cable is situated one-half mile below the railroad station in its original position. Changes in the channel necessitated the selection of a better location for the gage rod a few hundred feet nearer to the cable and one-fourth of a mile below the railroad station. A new wire gage was established October 29, 1902. It consists of a horizontal rod attached to a beam projecting over the water and spiked to the top of the cribbing on the left shore about 1[illegible] feet north of the railroad track. The length from the end of the weight to the marker is 14.333 feet and the distance from the outside edge of the pulley to the zero of the gage scale is 6.02 feet. The bench mark is a spike on the top timber of the cribbing. Its elevation is 8.31 feet above the zero of the new gage. The initial point for soundings is the face of the tree to which the cable is attached on the right bank of the stream. The channel is straight and the bed is of gravel.

The following discharge measurements were made during 1902:

July 21: Gage height, 0.90 foot; discharge, 130 second-feet.
October 29: Gage height, 0.65 foot; discharge, 106 second-feet.
December 20: Gage height, 1.60 feet; discharge, 381 second-feet.

Daily gage height, in feet, of Umatilla River at Gibbon, Oreg.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.35	1.00	2.50	1.85	2.65	2.60	0.95	0.80	0.75	0.85	0.65	2.[illegible]
2	1.30	1.00	2.45	2.00	3.10	2.40	1.10	.80	.75	.85	.70	1.[illegible]
3	1.30	1.00	2.25	2.10	3.35	2.25	1.55	.80	.75	.85	.70	1.[illegible]
4	1.35	1.00	2.15	2.25	3.50	2.05	2.20	.80	.75	.85	.70	1.7[illegible]
5	1.40	1.00	2.00	2.30	3.45	1.90	1.95	.80	.75	.85	.75	1.6[illegible]
6	1.40	1.05	1.85	2.80	3.20	1.80	1.60	.80	.75	.85	.80	1.5[illegible]
7	1.45	1.05	1.75	3.90	3.30	1.70	1.40	.80	.75	.85	1.10	1.5[illegible]
8	1.45	1.10	1.70	3.95	3.40	1.65	1.25	.75	.75	.90	1.20	1.5[illegible]
9	1.40	1.80	1.70	3.70	3.40	1.55	1.15	.75	.75	.90	1.20	3.[illegible]
10	1.40	2.50	1.75	3.40	3.45	1.50	1.10	.75	.75	.90	1.15	3.[illegible]
11	1.40	2.80	1.80	3.20	3.40	1.45	1.10	.75	.75	.90	1.10	2.[illegible]
12	1.40	2,80	1.90	2,95	3.30	1.40	1.05	.75	.75	.85	1.05	2.[illegible]
13	1.35	2.85	1.80	2.75	3.25	1.30	1.05	.75	.75	.85	1.00	2.3[illegible]
14	1.35	2.90	1.70	2.60	3.20	1.25	1.05	.75	.75	.85	1.20	2.[illegible]
15	1.35	2.90	1.65	2.45	3.10	1.20	1.05	,75	.75	.85	1.20	2.[illegible]
16	1.30	2.90	1.60	2.50	3.05	1.20	1.00	.80	.75	.85	1.45	1.[illegible]
17	1.30	3.50	1.70	2.60	3.00	1.15	.95	.80	.75	.85	1.70	1.5
18	1.30	3.60	1.90	3.20	2.90	1.15	.95	.80	.75	.85	1.75	1.6[illegible]
19	1.30	3.00	2.00	3.85	3.30	1.10	.90	.75	.85	.85	1.85	1.[illegible]
20	1.25	2.65	2.05	3.50	5.80	1.10	.90	.75	.85	.85	1.70	1.[illegible]
21	1.25	2.40	2.00	3.30	5.75	1.10	.90	.75	.85	.85	1.65	1.5
22	1.25	2.20	1.90	3.00	5.25	1.05	.90	.75	.85	.95	1.55	1.[illegible]
23	1.20	2.10	1.90	2.80	4.80	1.05	.90	.75	.85	1.00	1.45	1.[illegible]
24	1.20	2.25	1.90	2.65	4.40	1.05	.85	.75	.90	1.05	1.55	1.[illegible]
25	1.10	2.80	1.80	2.50	4.10	1.00	.85	.75	.90	1.05	1.60	1.[illegible]
26	1.10	2.75	1.75	2,40	3.90	1.00	.85	.75	.90	1.00	1.60	3.[illegible]
27	1.05	2.60	1.70	2.40	3.60	.95	.85	.75	.95	1.00	1.60	3.[illegible]
28	1.05	2.50	1.70	2.45	3.40	.95	.80	.75	.90	1.00	1.55	2.6[illegible]
29	1.05	.....	1.65	2.50	3.25	.95	.80	.75	.85	.65	1.55	2.4[illegible]
30	1.05	.....	1.70	2.60	3.00	.95	.80	.75	.85	.65	1.60	2.3[illegible]
31	1.00	.....	1.75	.....	2.75	.....	.80	.75	.....	.65	.....	2.0[illegible]

Rating table for Umatilla River at Gibbon, Oreg., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	50	1.4	330	2.8	1,100	4.5	2,555
.2	63	1.6	412	3.0	1,255	5.0	3,055
.4	78	1.8	502	3.2	1,415	5.5	3,555
.6	98	2.0	600	3.4	1,575	6.0	4,055
.8	135	2.2	707	3.6	1,735		
1.0	190	2.4	826	3.8	1,895		
1.2	256	2.6	957	4.0	2,055		

Estimated monthly discharge of Umatilla River at Gibbon, Oreg.

[Drainage area, 358 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	350	190	284	17,463	0.80	0.92
February	1,735	190	801	44,481	2.27	2.36
March	890	412	541	33,265	1.53	1.76
April	2,015	526	1,140	67,835	3.23	3.60
May	3,855	992	1,767	108,649	5.01	5.77
June	957	175	348	20,707	.99	1.10
July	707	135	228	14,019	.65	.75
August	135	124	128	7,870	.36	.42
September	175	124	136	8,093	.39	.44
October	206	106	155	9,531	.44	.51
November	526	106	302	17,970	.86	.96
December	1,415	330	668	41,074	1.89	2.18
The year	3,855	106	542	390,957	1.54	20.77

YAKIMA RIVER AT KIONA, WASH.

This station is the lowest point at which measurements have been made on Yakima River, and is located at the wagon bridge one-fourth mile north of the railroad station at Kiona. The gage was established August 20, 1895, and consisted of two parts, one vertical and the other inclined at an angle of 30°. It was spiked to the east end of the south pier and anchored with rocks. The initial point for soundings is on the west side of the bridge, 100 feet south of the center of the south pier of the main span. The channel for about 200 feet both above and below the station is nearly straight and the water is quite swift. The right bank is low, but is well protected by a levee, and not subject to overflow. The left bank is high and rocky. The bed of the stream is of gravel and affords an excellent cross section for discharge measurements.

A wire gage was afterwards placed on the lower side of the bridge. The distance from the end of the weight to the index marker is 27.21 feet. From the end of the rod to the outside edge of the pulley wheel it is 2 feet. A new bench mark was established in 1901. It is the top of an iron spike in the east end of the cap of the first trestle bent of the bridge approach on the south side of the river. The elevation of the bench mark above the zero of the gage is 20.53 feet and above sea level 474.24 feet. The top of the 2-inch pulley wheel of the wire gage is 4.68 feet above this bench mark. When the marker on the wire gage is at zero, the bottom of the weight has an elevation of 453.71 feet.

Discharge measurements of Yakima River at Kiona, Wash.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
March 25	Sydney Arnold	6.00	4,152
April 11	do	7.76	7,060
June 12	do	9.00	9,646
June 23	do	8.00	8,392
July 11	do	6.45	4,114
September 2	do	2.95	251
October 21	do	3.85	863

Daily gage height, in feet, of Yakima River at Kiona, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.55	5.40	6.42	6.25	9.85	10.00	(a)	5.00	2.98	3.78	4.31	5.15
2	8.58	5.30	6.35	6.33	9.90	9.20	(a)	4.96	2.95	3.95	4.35	5.52
3	8.60	5.25	6.30	6.35	9.90	8.85	(a)	4.82	2.95	3.93	4.38	5.93
4	8.64	5.20	6.45	6.42	9.95	8.30	(a)	4.73	2.94	3.90	4.40	6.70
5	8.70	5.10	6.45	6.45	10.05	8.18	(a)	4.70	2.93	3.80	4.40	6.50
6	8.80	5.00	6.50	6.60	10.15	8.20	(b)	4.65	2.90	3.72	4.42	6.35
7	8.85	5.00	6.60	6.75	10.25	8.15	(b)	4.70	2.90	3.68	4.53	6.15
8	8.95	4.95	6.70	6.90	10.30	8.07	(b)	4.80	2.90	3.65	4.58	5.95
9	9.00	5.00	6.70	7.25	10.40	7.98	(b)	4.85	2.90	3.65	4.60	5.90
10	9.15	5.05	6.64	7.70	10.68	8.02	(b)	4.72	2.88	3.65	4.78	5.85
11	8.43	5.05	6.50	7.73	10.90	8.00	6.45	4.55	2.88	3.65	4.92	5.85
12	8.10	5.10	6.55	7.65	11.40	7.95	6.43	4.30	2.88	3.65	5.05	5.70
13	7.90	5.15	6.55	7.45	11.60	7.90	6.42	4.22	2.88	3.65	5.12	5.60
14	7.75	5.20	6.60	7.25	11.40	7.78	6.40	4.10	2.88	3.64	5.18	5.50
15	7.50	5.50	6.60	7.10	11.25	7.70	6.20	3.97	2.90	3.63	5.20	5.39
16	7.05	6.13	6.55	7.00	11.00	7.65	6.26	3.90	2.98	3.70	5.22	5.30
17	6.75	7.00	6.50	7.00	10.95	7.56	6.28	3.85	3.00	3.78	5.31	5.25
18	6.75	7.12	6.45	7.15	10.80	7.42	6.25	3.85	3.00	3.80	5.38	5.20
19	6.70	7.10	6.38	7.25	10.40	7.38	6.18	3.78	3.03	3.82	5.70	5.14
20	6.68	7.16	6.35	7.40	9.98	7.30	6.08	3.70	3.01	3.87	5.75	5.07
21	6.65	7.20	6.25	7.45	9.45	(a)	6.09	3.60	3.08	3.85	5.65	4.97
22	6.55	7.20	6.20	8.10	9.15	(a)	6.38	3.52	3.08	3.88	5.55	4.92
23	6.50	7.05	6.15	8.40	9.25	8.00	6.24	3.45	3.20	3.90	5.40	4.86
24	6.50	6.95	6.05	8.75	9.45	(a)	6.14	3.35	3.20	3.92	5.34	4.80
25	6.35	6.80	6.00	9.10	9.60	7.57	6.02	3.16	3.20	4.00	5.30	4.90
26	6.25	6.75	6.10	9.20	9.85	7.54	5.92	3.13	3.20	4.07	5.27	4.99
27	6.00	6.60	6.10	9.35	10.20	7.55	5.82	3.10	3.22	4.13	5.24	5.30
28	5.90	6.50	6.13	9.40	11.00	7.55	5.66	3.08	3.35	4.18	5.20	5.52
29	5.90	.....	6.15	9.65	11.50	7.42	5.42	3.05	3.58	4.22	5.15	5.70
30	5.75	.....	6.15	9.85	11.30	7.40	5.27	2.98	3.65	4.25	5.10	5.68
31	5.60	.....	6.20	.....	10.85	.....	5.15	2.98	.....	4.27	.....	6.10

[a] Observer absent. [b] Gage broken.

Rating table for Yakima River at Kiona, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.8	200	5.8	3,310	8.8	9,340	11.8	17,480
3.0	270	6.0	3,630	9.0	9,780	12.0	18,080
3.2	370	6.2	3,970	9.2	10,240	12.2	18,680
3.4	490	6.4	4,320	9.4	10,700	12.4	19,280
3.6	620	6.6	4,680	9.6	11,160	12.6	19,880
3.8	760	6.8	5,060	9.8	11,620	12.8	20,480
4.0	910	7.0	5,450	10.0	12,080	13.0	21,080
4.2	1,070	7.2	5,850	10.2	12,680	13.2	21,680
4.4	1,260	7.4	6,270	10.4	13,280	13.4	22,280
4.6	1,490	7.6	6,700	10.6	13,880	13.6	22,880
4.8	1,760	7.8	7,140	10.8	14,480	13.8	23,480
5.0	2,060	8.0	7,580	11.0	15,080	14.0	24,080
5.2	2,365	8.2	8,020	11.2	15,680	14.2	24,680
5.4	2,675	8.4	8,460	11.4	16,280	14.4	25,280
5.6	2,990	8.6	8,900	11.6	16,880	.....	.....

Estimated monthly discharge of Yakima River at Kiona, Wash.

[Drainage area, 5,230 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	10,125	560	6,414	394,381	1.23	1.42
February	5,850	1,986	3,663	203,433	.70	.73
March	4,870	3,630	4,281	263,228	.82	.95
April	11,735	4,055	6,869	408,734	1.31	1.46
May	16,880	10,125	13,388	823,196	2.56	2.95
June	12,080	6,060	7,416	441,283	1.42	1.58
July	6,123	2,288	4,245	261,015	.81	.93
August	2,060	262	1,009	62,041	.19	.22
September	655	224	303	18,030	.06	.07
October	1,133	641	808	49,682	.15	.17
November	3,230	1,170	2,134	126,982	.41	.46
December	4,870	1,760	2,917	179,359	.56	.65
The year	16,880	224	4,454	3,231,364	.85	11.52

YAKIMA RIVER AT UNION GAP, WASH.

Yakima River enters Columbia River just above the town of Pasco. The first measurement of the river was made at this point on August 14, 1893. At that time there was an old vertical river rod attached to the central pier of the bridge. As the foot of this at low water was covered by rock and could not be read, an inclined gage was put in position at the west end of the county bridge. This consisted of two pieces of timber having a total length of 24 feet. These were firmly secured to timbers, bedded, and loaded with rock. The gage rod was painted white and lettered in vertical feet and tenths of a foot. After this new gage was located, it was ascertained that the readings on the old gage would be 1.13 feet higher than on the new. The zero of this new gage was 19.02 feet below the top of the rail of the Northern Pacific Railroad immediately west of the west end of the bridge, which was about 40 feet from the gage. The high-water mark at that time showed that a flood had risen to 8.80 feet on the old gage. Readings at this point were begun on October 2, 1893, and continued during the following winter and spring until May 19, 1894. Owing to the destruction of the gage by floods the station was for a time abandoned.

During August, 1895, Arthur P. Davis visited the locality and found that the section was not favorable for making discharge measurements. He accordingly selected the present station, which is located at Union Gap, 6 miles below North Yakima, Wash., and 1,000 feet

below the highway bridge. It is about 3 miles above the intake of the Sunnyside canal. The gage rod is inclined and is attached to a willow stump and posts set in the ground. The bench mark is the highest point of a large rock mound 43 feet north of the gage and 5.5 feet east of the fence, and is at an elevation of 17.52 feet above gage datum. The equipment consists of cable, car, and tagged wire. The station is of value as it is the only point near the large irrigated area above and below which is unaffected by the taking out of water in irrigating canals.

Discharge measurements of Yakima River at Union Gap, Wash.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
July 5	Sydney Arnold	6.75	5,352
September 3	do	4.10	917
November 3	do	4.55	1,391

Daily gage height, in feet, of Yakima River at Union Gap, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.60	5.30	6.00	5.60	7.40	9.00	7.00	5.60	4.10	4.60	4.40	6.00
2	6.60	5.20	6.20	5.60	7.30	8.30	7.00	5.60	4.10	4.60	4.40	6.30
3	6.40	5.20	6.20	5.50	7.30	7.90	6.90	5.30	4.10	4.60	4.40	6.60
4	6.30	5.00	6.30	5.50	7.50	7.50	6.90	5.10	4.10	4.60	4.60	6.60
5	6.90	5.00	6.30	5.50	7.80	7.50	6.70	5.10	4.10	4.50	4.60	6.30
6	7.00	5.00	6.20	5.90	8.00	7.30	6.70	5.10	4.10	4.50	4.60	6.00
7	7.40	5.00	6.30	7.00	8.20	7.30	6.60	5.10	4.10	4.40	4.60	6.00
8	7.60	4.90	6.30	7.60	8.20	7.20	6.60	5.00	4.10	4.40	4.60	5.90
9	8.00	5.10	6.30	7.60	8.80	7.40	6.60	5.00	4.10	4.40	4.60	5.90
10	8.20	5.10	6.30	7.60	8.90	7.50	6.30	4.90	4.00	4.20	4.60	5.60
11	8.00	5.30	6.20	7.00	9.50	7.90	6.30	4.90	4.00	4.20	4.80	5.60
12	7.60	5.30	6.20	6.90	10.10	8.20	6.30	4.90	4.00	4.20	5.00	5.30
13	7.20	5.30	6.20	6.90	10.10	8.00	6.10	4.90	4.00	4.20	5.10	5.30
14	6.90	5.30	6.20	6.90	9.80	7.90	6.10	4.80	4.00	4.30	5.20	5.30
15	6.70	5.30	6.20	6.90	9.50	7.50	6.10	4.80	4.00	4.30	5.20	5.30
16	6.60	5.70	6.00	7.00	9.50	7.50	6.00	4.70	4.00	4.30	5.40	5.20
17	6.40	6.60	6.00	7.00	9.50	7.30	6.00	4.70	4.00	4.30	5.40	5.10
18	6.40	6.60	6.00	7.10	9.50	7.30	6.00	4.60	4.00	4.40	5.40	5.00
19	6.20	7.00	5.90	7.30	9.30	7.30	6.00	4.60	4.10	4.40	5.60	4.90
20	6.00	7.00	5.90	7.90	9.30	7.30	6.00	4.50	4.10	4.40	5.60	4.90
21	5.90	6.90	5.90	8.10	8.90	7.00	6.00	4.50	4.10	4.40	5.50	4.90
22	5.90	6.90	5.90	8.00	8.30	7.00	5.90	4.40	4.10	4.40	5.40	5.00
23	5.70	6.90	5.80	7.90	8.00	7.30	5.90	4.40	4.10	4.30	5.30	5.00
24	5.70	6.90	5.80	7.90	8.00	7.30	5.90	4.30	4.10	4.30	5.30	5.30
25	5.40	6.60	5.80	7.80	9.00	7.80	5.90	4.30	4.10	4.30	5.40	5.60
26	5.40	6.60	5.80	7.80	9.40	7.80	5.90	4.30	4.10	4.30	5.50	5.60
27	5.20	6.30	5.70	7.60	9.80	7.80	5.80	4.20	4.10	4.30	5.50	5.80
28	5.20	6.00	5.70	7.50	10.20	7.60	5.80	4.20	4.40	4.30	5.60	5.80
29	5.00	.....	5.70	7.50	10.10	7.30	5.70	4.20	4.40	4.30	5.60	5.60
30	5.20	.....	5.70	7.40	9.80	7.30	5.70	4.20	4.50	4.30	5.80	5.60
31	5.40	.....	5.70	.....	9.50	.....	5.60	4.20	.....	4.40	.....	5.60

[a] Rating table for Yakima River at Union Gap, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
4.0	820	5.8	3,160	7.6	7,800	9.4	15,000
4.2	1,020	6.0	3,550	7.8	8,500	9.6	15,900
4.4	1,230	6.2	3,980	8.0	9,200	9.8	16,800
4.6	1,450	6.4	4,450	8.2	10,000	10.0	17,700
4.8	1,690	6.6	4,950	8.4	10,800	10.5	19,950
5.0	1,940	6.8	5,450	8.6	11,600	11.0	22,200
5.2	2,210	7.0	5,950	8.8	12,400	11.5	24,450
5.4	2,500	7.2	6,550	9.0	13,200	12.0	26,700
5.6	2,810	7.4	7,150	9.2	14,100		

[a] Measurements made since this table was constructed show that it is correct below a gage height of 5.00 feet; above that height the discharge given in the table is too low.

Estimated monthly discharge of Yakima River at Union Gap, Wash.

[Drainage area, 3,300 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	10,000	1,940	4,804	295,386	1.46	1.68
February	5,950	1,810	3,481	193,325	1.05	1.09
March	4,210	2,980	3,621	222,647	1.10	1.27
April	9,600	2,650	6,442	383,326	1.95	2.18
May	18,600	6,850	13,105	805,795	3.97	4.58
June	13,200	5,950	7,800	464,132	2.36	2.63
July	5,950	2,810	4,057	249,455	1.23	1.42
August	2,810	1,020	1,625	99,979	.49	.56
September	1,340	820	925	55,041	.28	.31
October	1,450	1,020	1,196	73,539	.36	.42
November	3,160	1,230	2,117	125,970	.64	.71
December	4,950	1,810	2,869	176,408	.87	1.00
The year	18,600	820	4,337	3,145,003	1.31	17.85

NACHES RIVER NEAR NORTH YAKIMA, WASH.

This station was established August 14, 1893, by F. H. Newell, at a point a few hundred yards above the mouth of Naches River, near the bridge of the Northern Pacific Railroad. The vertical gage was nailed to the cribwork on the right-hand side of the river, above the railroad bridge, and could be read easily from the track. The 12-foot mark was 9.97 feet below the top of the rail on the bridge, the gage being about 60 feet easterly from the rail. The top of the iron pier, on the southeast end of the county bridge, was 5.87 feet above this 12-foot mark. Measurements were made from the county bridge. The locality was, however, not favorable for the purpose, as the water is very swift, and was broken by the piers of the bridge. Owing to the difficulty of securing accurate measurements the readings were discontinued on September 20, 1894, and not resumed until August 19, 1895. The flood of November, 1896, modified the channel very greatly, depositing a large mass of coarse gravel and small bowlders along the right side of the channel at the section, so that the rod was about 50 feet from the edge of the water at low stages. The current is swift, even at low water. On account of the instability of the channel the station was abandoned in February, 1897, although a number of discharge measurements were made during the season. The station was located below the heads of a number of ditches. May 19, 1897, a station was established on Yakima River, 5 miles above the mouth of the Naches, at the Northern Pacific Railway bridge near Selah, Wash., with the idea that the difference in discharge between this station and the one at Union Gap would give approximately the discharge of Naches River. Two ditches, those of Moxee Valley, are taken out between the two points, but their amount is about counterbalanced by that received from Atanum Creek and the wastage at Old Town.

The North Yakima station was reestablished on February 1, 1898, and the station at Selah, on Yakima River, was discontinued. Since the reestablishment of the Naches station the river channel has been in a condition more favorable for meter observations than formerly. Discharge measurements are made from the lower side of the highway bridge. A new horizontal gage rod, with wire and weight, was attached to the main span of the Northern Pacific Railway bridge at the mouth of the Naches, a few hundred feet downstream from the highway bridge. The length of the gage wire from index to foot of weight was 30.41 feet. The pulley distance was 5.844 feet. The elevation of top of pulley was 24.57 feet. The bench mark was the top of the north end of east sill of clearance posts, about 150 feet north of Northern Pacific Railway bridge. Elevation, 23.766 feet above zero of gage. On December 27, 1898, Mr. Arnold connected the highway bridge with this bench mark. The top of the northeast

concrete pier was found to be at an elevation of 22.09 feet, and the top of the bridge post at the 150-foot mark at an elevation of 26.7[illegible] feet above zero. The distance from the top of the post to the surface of the water has been carefully measured at each discharge measurement, so that the exact river height at the highway bridge is known.

On June 20, 1901, the gage rod and bench mark having been disturbed during alterations to the railroad bridge and approaches, a new 4-inch by 4-inch inclined gage rod was established on the left bank of the river, 30 feet downstream from the railroad bridge. The bench mark is U.S.G.S. B.M. established by H. S. Crowe. It is a copper plug marked "1090 T." Its elevation is 1,089.959 feet above sea level. It is located on Naches River opposite the point where it empties into Yakima River, in the center of the west end of the stone pier of the railroad bridge. The elevation of the zero of the gage is 1,070.22 feet above sea level. The initial point for measurements is the center of the east pier of the highway bridge. The lower section of the gage rod is inclined at an angle of 36° 30′ with the horizontal. The upper section is inclined at an angle of 80°.

Owing to unfavorable conditions at the highway bridge due to the accumulation of drift and a changing channel, a cable station has been established between the highway bridge and the railway bridge. A careful measurement under favorable conditions made in 1903 at the new station made by Geo. H. Bliss gave a discharge of 4[illegible] second-feet at 5.25 feet of gage height.

Discharge measurements of Naches River near North Yakima, Wash.

Date.	Hydrographer.	Gage height.	Discharge
1902.		*Feet.*	*Second-feet.*
April 14	Sydney Arnold	6.65	1,65[illegible]
April 30	do	7.20	2,58[illegible]
May 8	do	8.45	5,7[illegible]
June 13	do	7.80	3,81[illegible]
August 28	do	5.20	[illegible]
August 28	do	5.20	[a] 52[illegible]
November 4	do	5.45	45[illegible]

[a] Measured at Nelson bridge, 4 miles above gaging station.

Daily gage height, in feet, of Naches River near North Yakima, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	6.50	5.80	6.50	6.20	7.20	8.10	7.80	6.20	5.20	5.40	5.50	6.20
2	6.40	5.80	6.40	6.20	7.10	7.90	7.30	6.10	5.20	5.40	5.60	6.40
3	6.40	5.80	6.30	6.30	7.10	7.60	7.20	6.05	5.20	5.40	5.70	6.20
4	6.60	5.80	6.30	6.30	7.20	7.40	7.20	6.00	5.10	5.40	5.60	6.10
5	7.05	5.80	6.30	6.30	7.30	7.40	7.10	6.00	5.10	5.30	5.60	6.10
6	7.50	5.80	6.30	6.90	7.50	7.30	7.05	5.90	5.10	5.20	5.50	6.00
7	7.50	5.80	6.30	7.50	7.90	7.30	7.00	5.90	5.10	5.20	5.50	5.95
8	8.40	5.80	6.40	7.60	8.90	7.70	6.90	5.90	5.10	5.20	5.60	5.90
9	8.20	5.75	6.45	7.30	8.70	8.10	6.80	5.80	5.10	5.20	5.80	6.00
10	7.80	5.70	6.50	7.20	8.80	8.20	6.80	5.80	5.10	5.20	6.00	6.10
11	7.60	5.70	6.50	6.90	8.85	8.20	6.80	5.80	5.10	5.20	6.00	6.10
12	7.50	5.70	6.50	6.80	8.90	8.10	6.80	5.70	5.10	5.20	6.00	6.10
13	7.40	5.70	6.50	6.75	8.80	7.90	6.80	5.70	5.10	5.20	6.00	6.10
14	7.20	5.70	6.40	6.70	8.80	7.80	6.80	5.60	5.05	5.20	6.10	6.00
15	6.90	5.80	6.40	6.80	8.70	7.75	6.80	5.60	5.00	5.20	6.10	5.90
16	6.70	6.40	6.30	6.90	8.60	7.70	6.80	5.50	5.00	5.30	6.20	5.80
17	6.60	7.00	6.20	7.40	8.50	7.70	6.80	5.50	5.00	5.40	6.30	5.80
18	6.50	7.00	6.20	7.50	8.30	7.70	6.70	5.50	5.00	5.50	6.40	5.70
19	6.45	6.90	6.20	8.20	8.10	7.60	6.70	5.50	5.00	5.50	6.30	5.70
20	6.40	6.90	6.20	8.05	7.80	7.60	6.70	5.40	5.00	5.50	6.10	5.70
21	6.40	6.80	6.20	7.90	7.80	7.60	6.70	5.40	5.00	5.50	6.00	5.70
22	6.30	6.70	6.20	7.80	7.70	7.80	6.70	5.40	5.00	5.40	5.90	5.70
23	6.20	6.70	6.15	7.70	7.90	8.00	6.70	5.30	5.00	5.40	5.90	5.80
24	6.10	6.70	6.10	7.60	8.10	8.10	6.60	5.30	5.00	5.40	5.90	5.80
25	5.80	6.70	6.10	7.50	8.25	8.10	6.60	5.30	5.00	5.40	5.80	6.00
26	5.80	6.70	6.10	7.50	8.40	7.90	6.50	5.30	5.20	5.40	5.80	6.20
27	5.80	6.60	6.10	7.45	9.00	7.80	6.40	5.20	5.30	5.40	5.80	6.60
28	5.80	6.60	6.10	7.40	9.40	7.60	6.30	5.20	5.40	5.40	5.70	6.50
29	5.80	.....	6.10	7.30	9.20	7.45	6.30	5.20	5.50	5.40	5.70	6.40
30	5.80	.....	6.10	7.20	8.70	7.30	6.20	5.20	5.50	5.40	5.95	6.40
31	5.80	.....	6.10	.....	8.30	.....	6.20	5.20	.....	5.40	.....	6.30

Rating table for Naches River at North Yakima, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
5.0	200	6.2	1,125	7.4	2,950	8.6	6,290
5.2	300	6.4	1,350	7.6	3,360	8.8	6,830
5.4	425	6.6	1,595	7.8	3,810	9.0	7,470
5.6	570	6.8	1,860	8.0	4,370		
5.8	735	7.0	2,152	8.2	5,010		
6.0	920	7.2	2,580	8.4	5,650		

Estimated monthly discharge of Naches River near North Yakima, Wash.

[Drainage area, 1,000 square miles.]

Month.	Discharge in second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Second-feet per square mile.	Depth in inches.
1902.						
January	5,650	735	1,943	119,470	1.94	2.2[illegible]
February	2,152	650	1,210	67,200	1.21	1.[illegible]
March	1,470	1,020	1,211	74,461	1.21	1.[illegible]
April	5,010	1,125	2,638	156,972	2.64	2.[illegible]
May	8,750	2,311	5,282	324,777	5.28	6.[illegible]
June	5,010	2,760	3,782	225,045	3.78	4.[illegible]
July	2,760	1,125	1,845	113,445	1.85	2.[illegible]
August	1,125	300	589	36,216	.59	.6[illegible]
September	495	200	263	15,650	.26	.2[illegible]
October	495	300	390	23,919	.39	.4[illegible]
November	1,350	495	820	48,793	.82	.9[illegible]
December	1,595	650	975	59,950	.98	1.1[illegible]
The year	8,750	200	1,746	1,265,898	1.74	23.7[illegible]

TIETON RIVER NEAR NORTH YAKIMA, WASH.

The gaging station on this stream was established April 14, 1902, at a point immediately below the mouth of Oak Creek, in sec. 3, T. 14 N., R. 16 E. of the Willamette meridian, and about 22 miles from North Yakima by road. The gage rod is inclined at an angle of 55 with the horizontal and is on the left bank of the stream. It consists of a 1 by 5 inch cedar plank supported and braced by stout logs. The equipment with which measurements are made consists of a five-eighth-inch galvanized-iron cable supporting a wooden car, tag wire, and stay wire. The initial point for soundings is a cross chiseled in a ledge with a black ring painted around it. It is under the cable, 4 feet east of the west shear legs. The observer is Omer Tetherow, a farmer. There are no side channels and the banks are not subject to overflow. The bed of the stream is rocky, with shifting gravel bars, which make it difficult to find suitable cross-sections for meter measurements. The point selected for the station is, however, a fairly good one, and the channel is straight both above and below the station for several hundred yards.

Discharge measurements of Tieton River near North Yakima, Wash.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
June 21	Sydney Arnold	8.90	1,471
June 28	do	8.55	1,106
July 16	do	8.45	906
August 25	do	7.30	392
September 16	do	6.90	306
October 27	do	6.55	228
November 29	do	6.80	289

Daily gage height, in feet, of Tieton River near North Yakima, Wash.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1		8.10	8.85	8.60	7.98	7.10	6.80	6.60	7.98
2		8.00	8.70	8.43	7.83	7.12	6.75	6.73	7.45
3		8.00	8.55	8.30	7.70	7.15	6.75	6.80	7.30
4		8.00	8.45	8.35	7.68	7.20	6.73	6.70	7.25
5		8.10	8.40	8.50	7.68	7.13	6.72	6.60	7.08
6		8.40	8.40	8.28	7.68	7.20	6.72	6.65	7.00
7		8.80	8.40	8.13	7.83	7.26	6.75	6.75	7.00
8		9.40	8.70	8.13	7.88	7.25	6.75	7.23	7.00
9		9.60	9.25	8.20	7.75	7.18	6.72	7.33	7.00
10		9.75	9.30	8.20	7.70	7.15	6.75	7.18	7.50
11		9.90	9.20	8.25	7.55	7.05	6.75	7.13	7.33
12		9.50	8.95	8.25	7.65	7.03	6.73	7.08	7.23
13		9.40	8.90	8.10	7.53	6.92	6.68	6.95	7.10
14		9.40	8.85	8.13	7.53	7.00	6.70	6.93	6.95
15		9.40	8.85	8.28	7.48	7.05	6.70	6.90	7.00
16		9.60	8.90	8.40	7.43	6.95	6.90	7.13	7.48
17		9.25	8.60	8.20	7.33	6.87	6.93	7.45	6.65
18		9.05	8.65	8.13	7.23	6.82	6.80	7.35	6.63
19		8.85	8.65	8.25	7.18	6.85	6.70	7.18	6.58
20		8.70	8.80	8.35	7.20	6.82	6.70	7.13	6.98
21		8.60	8.90	8.40	7.23	6.75	6.65	7.05	8.80
22		8.70	9.03	8.30	7.28	6.75	6.70	7.00	6.90
23		8.70	9.30	8.30	7.28	6.72	6.60	6.93	6.85
24	8.50	8.80	9.33	8.23	7.25	6.75	6.60	6.95	6.68
25	8.40	9.00	9.23	8.13	7.22	6.72	6.60	6.90	7.40
26	8.40	9.45	8.88	8.10	7.25	6.72	6.60	6.85	8.10
27	8.30	10.05	8.75	8.18	7.15	7.27	6.60	6.85	7.60
28	8.30	10.20	8.63	7.93	7.20	7.03	6.70	6.85	7.50
29	8.30	9.65	8.50	7.80	7.10	6.88	6.75	6.80	7.33
30	8.20	9.30	8.62	7.73	7.10	6.83	6.65	6.85	7.25
31		9.05		7.95	7.05		6.65		7.28

Rating table for Tieton River near North Yakima, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
6.0	120	7.2	372	8.4	900	9.6	2,310
6.2	160	7.4	420	8.6	1,110	9.8	2,550
6.4	200	7.6	484	8.8	1,350	10.0	2,790
6.6	240	7.8	560	9.0	1,590		
6.8	284	8.0	640	9.2	1,830		
7.0	328	8.2	750	9.4	2,070		

Estimated monthly discharge of Tieton River near North Yakima, Wash.

[Drainage area, 289 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
May	3,030	640	1,693	104,100	5.86	6.76
June	1,986	900	1,378	82,000	4.77	5.32
July	1,110	533	779	47,900	2.70	3.11
August	682	339	450	27,670	1.56	1.80
September	390	269	327	19,460	1.13	1.26
October	313	236	265	16,290	.92	1.06
November	485	240	321	19,100	1.11	1.24
December	1,350	236	409	25,150	1.42	1.64

SPOKANE RIVER AT SPOKANE, WASH.

The falls at Spokane, aggregating 142 feet in height, have been utilized to a considerable extent by a number of flour mills, as well as by the power plant of the Washington Water Power Company, which furnishes electric power for the street-car service and for the lighting of the city. The river station established by C. C. Babb, October 17, 1896, is a short distance above Spokane Falls, at the bridge of the Oregon Railway and Navigation Company. The rod of the first wire gage was fastened to the upper guard rail in the west span of the bridge. The distance from the end of the weight to the index was 22.00 feet, and from the zero of the rod to the outside edge of the pulley 1.80 feet. The gage was connected with a bench mark of the city engineering department and referred to sea level, the rod datum being 1,880 feet above sea level. The channel is straight for some distance above and below the section. The bed is gravelly and is practically unchangeable. The banks are high and are only overflowed during extraordinary floods.

During 1901 new gages and bench marks were established at this point. The bench mark is a railroad spike driven into the electric-light pole close to and on the south side of the railroad track, at the west end of the bridge, at an elevation of 1,896.86 feet. The new wire gage on the north side of the west span of the bridge is the one used for recording the gage height. The zero of this gage is at an elevation of 1,879.35 feet, coinciding exactly with the position of the zero of the old gage. The distance from the end of the weight to the marker is 22 feet, the same as for the old gage, but the distance from the zero of the rod to the outside edge of the pulley is now 1.90 feet. As a safeguard, a new vertical gage rod has also been placed on the west face of the west pier of the bridge, the datum of which corresponds with that of the wire gage.

The Oregon Railway and Navigation Company's bridge to which the gage is fastened and from which measurements of flow are taken, has been under reconstruction during 1902, so that no gagings could be made during that year. The bed of the river, however, has not changed, and the 1901 rating table is applicable for the 1902 discharges.

Daily gage height, in feet, of Spokane River at Spokane, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.20	3.15	4.70	3.70	6.00	9.60	4.55	3.80	2.15	1.75	1.70	3.00
2	3.20	3.10	4.75	3.70	6.00	9.40	4.45	3.75	2.10	1.75	1.70	3.00
3	3.20	3.00	4.80	3.70	6.00	9.20	4.45	3.65	2.05	1.75	1.70	3.05
4	3.20	3.00	4.80	3.70	6.00	9.00	4.55	3.55	2.00	1.75	1.75	3.05
5	3.20	2.95	4.80	3.75	6.05	8.75	4.85	3.45	2.00	1.75	1.75	3.05
6	3.25	2.90	4.75	3.85	6.05	8.50	6.05	3.40	2.00	1.75	1.75	3.05
7	3.30	2.80	4.75	3.95	6.05	7.90	6.45	3.30	2.00	1.75	1.75	3.05
8	3.50	2.80	4.70	4.10	6.15	7.80	6.90	3.20	2.00	1.75	1.75	3.00
9	3.90	2.80	4.70	4.45	6.40	7.60	7.05	3.10	2.00	1.75	1.90	3.00
10	4.25	2.85	4.70	4.70	6.60	7.40	7.10	3.05	1.95	1.70	2.25	3.05
11	4.45	2.80	4.70	4.90	6.95	7.20	7.05	3.00	1.90	1.70	2.50	3.15
12	4.70	2.80	4.70	5.00	7.20	7.20	6.95	2.95	1.90	1.70	2.60	3.25
13	4.70	2.80	4.70	5.00	7.40	7.00	6.80	2.90	1.90	1.70	2.70	3.35
14	4.70	2.80	4.70	5.00	7.60	7.00	6.65	2.85	1.90	1.70	2.80	3.50
15	4.70	2.75	4.75	5.00	7.75	6.80	6.50	2.75	1.90	1.70	2.85	3.55
16	4.60	2.75	4.70	5.00	8.00	6.70	6.30	2.75	1.85	1.70	2.90	3.50
17	4.55	2.80	4.65	5.00	8.25	6.50	6.15	2.70	1.85	1.70	2.90	3.45
18	4.40	2.95	4.60	5.00	8.40	6.15	5.95	2.65	1.80	1.65	3.00	3.45
19	4.30	3.30	4.50	5.10	8.50	6.05	5.75	2.60	1.80	1.60	3.10	3.35
20	4.30	3.65	4.45	5.30	8.50	6.00	5.60	2.60	1.75	1.60	3.30	3.25
21	4.20	3.85	4.40	5.55	8.55	5.80	5.45	2.50	1.75	1.60	3.30	3.20
22	4.10	3.95	4.35	5.80	8.70	5.70	5.25	2.50	1.75	1.55	3.25	3.15
23	4.05	4.10	4.25	5.90	9.05	5.55	5.10	2.50	1.75	1.55	3.25	3.15
24	3.95	4.10	4.20	6.00	9.40	5.40	5.00	2.50	1.75	1.55	3.25	3.10
25	3.80	4.20	4.15	6.05	9.70	5.30	4.90	2.45	1.75	1.50	3.15	3.05
26	3.70	4.35	4.10	6.10	9.80	5.15	4.70	2.35	1.75	1.50	3.15	3.05
27	3.60	4.50	4.05	6.05	9.80	5.00	4.50	2.35	1.75	1.50	3.05	3.05
28	3.45	4.60	4.00	6.05	9.70	4.90	4.40	2.30	1.75	1.60	3.00	3.05
29	3.35	.....	3.90	6.05	9.70	4.75	4.30	2.25	1.75	1.60	2.95	3.10
30	3.25	.....	3.85	6.00	9.70	4.65	4.20	2.20	1.75	1.60	2.95	3.15
31	3.20	.....	3.80	.....	9.70	.....	4.00	2.20	.....	1.60	.....	3.15

Rating table for Spokane River at Spokane, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	1,341	3.8	6,523	6.6	14,253	9.4	23,800
1.2	1,611	4.0	7,000	6.8	14,885	9.6	24,531
1.4	1,897	4.2	7,489	7.0	15,525	9.8	25,269
1.6	2,199	4.4	7,990	7.2	16,173	10.0	26,012
1.8	2,517	4.6	8,503	7.4	16,829	10.2	26,759
2.0	2,851	4.8	9,028	7.6	17,493	10.4	27,510
2.2	3,200	5.0	9,565	7.8	18,165	10.6	28,265
2.4	3,566	5.2	10,114	8.0	18,845	10.8	29,024
2.6	3,946	5.4	10,673	8.2	19,533	11.0	29,787
2.8	4,340	5.6	11,243	8.4	20,228	11.2	30,554
3.0	4,749	5.8	11,824	8.6	20,928	11.4	31,325
3.2	5,172	6.0	12,416	8.8	21,636	11.6	32,099
3.4	5,609	6.2	13,019	9.0	22,351	11.8	32,875
3.6	6,059	6.4	13,631	9.2	23,073	12.0	33,653

Estimated monthly discharge of Spokane River at Spokane, Wash.

[Drainage area, 4,005 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	8,764	5,172	6,759	415,595	1.69	1.95
February	8,503	4,241	5,453	302,844	1.36	1.42
March	9,028	6,523	8,215	505,121	2.05	2.36
April	12,716	6,289	9,618	572,311	2.40	2.68
May	25,269	12,416	18,558	1,141,087	4.63	5.34
June	24,531	8,634	15,110	899,107	3.77	4.21
July	15,848	7,000	11,223	690,075	2.80	3.23
August	6,523	3,200	4,464	274,481	1.11	1.28
September	3,112	2,437	2,647	157,507	.66	.74
October	2,437	2,046	2,289	140,745	.57	.66
November	5,389	2,356	4,010	238,612	1.00	1.12
December	5,946	4,749	5,115	314,509	1.28	1.48
The year	25,269	2,046	7,788	5,651,994	1.94	26.47

MISSOULA RIVER AT MISSOULA, MONT.

This station, established July 10, 1898, is located at Higgins Avenue bridge in Missoula. The river at this point flows in two channels, and in order to study their fluctuations a second rod was placed on the south channel January 28, 1899. This second rod is vertical and attached to the pier of the bridge. The readings of the two rods were made to correspond on the date of the establishment of the second rod. The original rod is known as rod No. 1, and the gage in the south channel is known as rod No. 2. Discharge measurements are always made at the bridge of the Bitterroot Valley division of the Northern Pacific Railway, some distance below the Higgins Avenue bridge. The river at this point is practically in one channel, except in times of flood, when some water finds its way through a slough 600 feet south of the bridge. On account of the difficulty of accurately measuring the fluctuations of the river at rods Nos. 1 and 2 a third rod was placed May 27, 1899, below the junction of the two branches and 150 yards east of the railroad bridge. The rod at this point consists of a horizontal 20-foot timber bolted to a cottonwood tree immediately below the buildings of the Garden City Bottling Works. The rod is securely braced with timbers both above and below and guyed by wires on both sides. To the horizontal timber is attached a wire gage, the length of which is 22 feet. The bench mark consists of a United States Geological Survey iron post, at the junction of McCormick and West Cedar streets, 100 yards east of the gage, on the north side of the highway. Its elevation above sea is 3,194.642 feet. The top of the horizontal bar of the gage, at a point exactly over the iron bolt which holds the rod to the cottonwood tree, is 3,178.338 feet. The height of the river was read at the three rods during 1899, but all subsequent readings have been made from No. 3.

During 1902 the following discharge measurements were made by H. B. Waters:

April 24: Gage height, 4.61 feet; discharge, 2,570 second-feet.
April 24: Gage height, 4.59 feet; discharge, 2,542 second-feet.
July 12: Gage height, 5.97 feet; discharge, 5,302 second-feet.
August 27: Gage height, 4.02 feet; discharge, 1,941 second-feet.

Daily gage height, in feet, of Missoula River at Missoula, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	(a)	(a)	3.88	3.70	4.73	9.72	5.87	4.67	3.90	3.90	3.87	[illegible]
2	.....	.....	3.83	3.68	4.80	9.47	5.92	4.57	3.90	3.80	3.8[illegible]	[illegible]
3	.....	.....	3.75	3.73	4.83	9.15	6.15	4.42	3.85	3.80	3.80	[illegible]
4	.....	.....	3.73	3.90	4.85	8.90	6.47	4.45	3.82	3.82	3.80	[illegible]
5	.....	.....	3.78	4.40	4.80	8.50	6.50	4.40	3.77	4.05	3.82	.....
6	.....	.....	3.80	4.35	4.73	8.00	6.70	4.35	3.87	3.87	3.80	[illegible]
7	.....	.....	3.80	4.53	4.88	7.75	6.57	4.32	3.72	3.77	3.82	.....
8	.....	.....	3.88	4.78	5.23	7.57	6.37	4.27	3.80	3.77	3.98	.....
9	.....	(a)	3.85	4.80	5.65	7.42	6.27	4.25	3.77	3.80	4.10	.....
10	.....	.....	3.93	4.53	6.35	8.23	6.15	4.35	3.77	3.82	4.18	[illegible]
11	.....	.....	3.93	4.30	6.78	8.32	6.10	4.15	3.70	3.85	4.22	[illegible]
12	.....	.....	3.90	4.13	7.28	8.20	6.05	4.15	3.72	3.90	4.20	[illegible]
13	.....	.....	3.90	4.13	8.18	7.90	5.97	4.12	3.75	3.85	4.20	[illegible]
14	.....	.....	3.88	4.05	7.72	7.67	5.82	4.15	3.70	3.83	4.15	[illegible]
15	.....	(a)	3.78	4.05	8.65	7.60	5.75	4.30	3.72	3.85	4.15	[illegible]
16	.....	.....	3.63	4.10	9.52	7.45	5.65	4.25	3.75	3.80	4.10	.....
17	3.25	.....	3.75	4.23	9.42	7.32	5.60	4.17	3.80	3.85	4.00	.....
18	.....	.....	3.75	4.55	9.20	6.82	5.75	4.32	3.77	3.87	4.00	[illegible]
19	.....	.....	3.75	4.73	8.77	6.62	5.80	4.30	3.80	3.80	4.02	.....
20	.....	.....	3.73	4.83	8.60	6.47	5.65	4.27	3.82	3.80	3.95	.....
21	.....	.....	3.73	4.88	8.75	6.37	5.55	4.17	3.97	3.80	3.90	.....
22	.....	(a)	3.75	4.80	9.10	6.25	5.42	4.15	3.80	3.80	3.80	.....
23	.....	.....	3.58	4.63	9.22	6.27	5.35	4.10	3.80	3.80	3.70	.....
24	(a)	.....	3.53	4.60	9.22	6.35	5.22	4.10	3.82	3.83	3.72	[illegible]
25	.....	.....	3.60	4.60	9.22	6.32	5.15	4.12	3.75	3.87	3.70	.....
26	.....	4.05	3.75	4.58	9.22	6.27	5.07	4.05	3.80	3.87	3.70	.....
27	.....	4.05	3.85	4.65	9.55	6.27	4.97	4.00	3.87	3.87	3.65	.....
28	.....	4.03	3.80	4.63	9.80	6.12	4.92	4.00	3.82	3.85	3.60	[illegible]
29	.....	.....	3.70	4.43	10.15	6.05	4.85	3.95	3.80	3.85	3.70	[illegible]
30	.....	.....	3.48	4.50	10.18	5.95	4.82	3.90	3.97	3.80	3.80	[illegible]
31	(a)	.....	3.53	.....	9.80	.....	4.75	3.90	.....	3.83	.....	[illegible]

a Ice at gage.

Rating table for Missoula River at Missoula, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.4	1,525	5.2	3,610	7.0	7,695	8.8	12,850
3.6	1,650	5.4	4,010	7.2	8,200	9.0	13,475
3.8	1,780	5.6	4,435	7.4	8,750	9.2	14,120
4.0	1,940	5.8	4,875	7.6	9,250	9.4	14,725
4.2	2,115	6.0	5,325	7.8	9,810	9.6	15,425
4.4	2,320	6.2	5,790	8.0	10,400	9.8	16,125
4.6	2,570	6.4	6,230	8.2	11,000	10.0	16,825
4.8	2,870	6.6	6,740	8.4	11,610		
5.0	3,240	6.8	7,205	8.6	12,250		

Estimated monthly discharge of Missoula River at Missoula, Mont.

[Drainage area, 5,960 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
March	1,900	1,580	1,766	108,587	0.30	0.35
April	3,050	1,715	2,383	141,798	.40	.45
May	17,350	2,787	10,236	629,387	1.72	1.98
June	15,775	5,212	8,852	526,771	1.49	1.66
July	6,975	2,787	4,725	290,529	.79	.91
August	2,687	1,865	2,136	131,338	.36	.42
September	1,865	1,715	1,778	105,798	.30	.33
October	1,980	1,750	1,808	111,170	.30	.35
November	2,215	1,650	1,875	111,570	.31	.35
December, 14 days			2,236	62,091	.38	.20

BITTERROOT RIVER NEAR GRANTSDALE, MONT.

This station was established April 25, 1902, by H. B. Waters. It is located on the highway bridge 2 miles southwest of Grantsdale and 5 miles southwest of Hamilton, Mont. The gage is the usual wire type fastened to the downstream truss of the bridge. It is graduated to feet and tenths and is read daily by T. J. Holt who lives about a quarter of a mile north of the gage. The stream at this section is straight and has a moderate velocity. The right bank has a gentle slope and is liable to overflow. The left bank is high and rocky. The bed of the stream is composed of gravel and bowlders. Bench mark No. 1 is a wire nail driven in the northeast side of a large pine stump and marked B. M. 24.40. The stump is across the road from the west end of the bridge. The elevation above the zero of the gage, 24.40 feet. Bench mark No. 2 is the northwest bolt in the northwest abutment plate of the bridge. It is marked B. M. 19.36. Its elevation above the zero of the gage is 19.36 feet.

Discharge measurements of Bitterroot River near Grantsdale, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 25	H. B. Waters	2.57	1,098
Do	do	2.55	1,057
July 11	do	3.38	2,423
August 26	do	1.50	247
Do	do	1.50	247
November 29	J. S. Baker	1.72	345

Daily gage height, in feet, of Bitterroot River near Grantsdale, Mont.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1		2.50	5.80	3.50	2.30	1.40	1.40	1.60	1.8[illegible]
2		2.60	5.60	3.40	2.30	1.30	1.40		1.8[illegible]
3		2.50	5.00	3.70	2.20	1.30	1.40		1.8[illegible]
4		2.40	4.90	3.70	2.20	1.30	1.50		1.8[illegible]
5		2.40	4.70	4.00	2.10	1.20	1.50		1.8[illegible]
6		2.50	4.50	3.80	2.10	1.20	1.50		1.7[illegible]
7		2.80	4.50	3.70	2.00	1.10	1.50		1.8[illegible]
8		3.30	4.70	3.50	2.00	1.10	1.60		1.8[illegible]
9		4.00	5.50	3.30	1.90	1.10	1.60	1.80	1.8[illegible]
10		4.60	6.30	3.40	1.90	1.20	1.60	1.80	2.0[illegible]
11		4.80	5.70	3.50	1.90	1.20	1.60	1.80	2.0[illegible]
12		5.00	5.40	3.60	1.90	1.10	1.60	1.80	1.9[illegible]
13		5.20	5.20	3.50	1.80	1.10	1.50	1.70	1.9[illegible]
14		5.80	5.00	3.40	1.80	1.10	1.40	1.70	1.8[illegible]
15		6.20	4.70	3.30	1.80	1.10	1.40	1.70	1.9[illegible]
16		6.00	4.50	3.30	1.80	1.20	1.40	1.70	2.0[illegible]
17		5.40	4.30	3.20	1.80	1.20	1.40	1.70	1.8[illegible]
18		4.90	4.40	3.20	1.80	1.30	1.50	1.70	1.8[illegible]
19		4.50	4.00	3.10	1.80	1.20	1.50	1.70	1.8[illegible]
20		4.10	4.00	3.00	1.80	1.30	1.50	1.70	2.0[illegible]
21		3.90	4.00	3.00	1.70	1.30	1.50	1.70	2.0[illegible]
22		3.80	4.10	3.00	1.70	1.30	1.60	1.70	2.0[illegible]
23		3.80	4.50	2.90	1.70	1.30	1.60	2.00	2.0[illegible]
24		4.00	4.60	2.90	1.60	1.40	1.50	2.10	2.0[illegible]
25	2.50	4.20	4.30	2.80	1.60	1.40	1.50	1.60	2.1[illegible]
26	2.60	4.50	4.10	2.80	1.60	1.40	1.50	1.60	2.0[illegible]
27	2.60	5.50	4.00	2.70	1.50	1.40	1.50	1.60	1.9[illegible]
28	2.60	6.20	3.90	2.60	1.50	1.40	1.50	1.60	1.9[illegible]
29	2.50	6.80	3.80	2.50	1.50	1.40	1.50	1.70	1[illegible]
30	2.50	6.20	3.70	2.50	1.40	1.30	1.50	1.70	1.8[illegible]
31		6.00		2.40	1.40		1.60		1.9[illegible]

Rating table for Bitterroot River near Grantsdale, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	125	2.4	900	3.8	3,255	5.2	6,380
1.2	150	2.6	1,150	4.0	3,700	5.4	6,855
1.4	205	2.8	1,430	4.2	4,140	5.6	7,325
1.6	280	3.0	1,745	4.4	4,575	5.8	7,790
1.8	395	3.2	2,085	4.6	5,005	6.0	8,340
2.0	530	3.4	2,450	4.8	5,440	6.2	8,970
2.2	700	3.6	2,850	5.0	5,900		

Estimated monthly discharge of Bitterroot River near Grantsdale, Mont.

[Drainage area, 1,550 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 25–30	.....	.....	1,085	12,912	0.70	0.16
May	11,075	900	4,823	296,555	3.11	3.59
June	9,285	3,050	5,176	307,993	3.34	3.73
July	3,700	900	2,143	131,768	1.38	1.59
August	790	205	428	26,316	.28	.32
September	205	135	167	9,937	.11	.12
October	280	205	242	14,879	.16	.18
November	615	280	353	21,005	.23	.26
December	1,150	340	472	29,022	.30	.35

PALOUSE RIVER NEAR HOOPER, WASH.

For some distance above Hooper, Palouse River consists of a succession of deep pools, from 10 to 15 feet in depth, connected by short riffles. Its valley is about one-half mile in width and bordered with basaltic cliffs approximately 300 feet in height.

The measurements of Palouse River are of value in showing the amount of water that could be utilized for irrigation on the lands of Washtucna Valley, and in the section north of Pasco. The gaging station was established April 1, 1897, by the land department of the Northern Pacific Railroad. September 9, 1897, the Geological Survey took charge of the station, placing the gage rod 1 mile below the former location and opposite the water tank, and stretching a cable across the river for discharge measurements. The rod is inclined, and fastened

to posts driven into the right bank. The bench mark is a point of rock, marked with red paint, on a ledge on the left bank of the river opposite the gage, and its elevation is 7.60 feet above datum. When the new gage reads 2.1 feet the height on the Northern Pacific Railroad gage is 6.1 feet. The channel is gravelly and not liable to change. The left bank is high and can not overflow. The right bank overflows at extreme high water. The initial point for sounding is the cable post on the left bank. The station is about 3 miles above the mouth of Cow Creek, and 2 miles below the head of the ditch of the Palouse Irrigation Company, carrying 25 second-feet when full. No measurements were made during 1901, the rating table for 1900 being used for that year. The 1902 table gives larger discharges, and it is probable that the discharges as published for 1901 are too small.

The following discharge measurements were made during 1902:

July 10: Gage height, 3.80 feet; discharge, 532 second-feet.
November 6: Gage height, 0.85 foot; discharge, 71 second-feet.

Daily gage height, in feet, of Palouse River near Hooper, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.30	1.60	5.80	3.00	2.70	3.20	1.35	1.20	0.60	0.70	0.75	1.60
2	2.25	1.50	5.50	2.90	2.70	3.00	1.35	1.20	.60	.70	.80	1.65
3	2.15	1.50	5.30	2.90	2.65	3.00	1.30	1.20	.60	.75	.85	3.30
4	2.20	1.50	5.05	3.00	2.65	3.00	1.40	1.20	.60	.80	.85	3.00
5	2.25	1.60	4.60	3.20	2.65	2.70	1.60	1.20	.60	.80	.85	2.90
6	2.20	1.80	4.30	3.40	3.40	2.60	1.80	1.20	.60	.80	.85	3.90
7	2.50	2.10	4.20	3.40	3.40	2.40	4.90	1.20	.60	.80	1.00	3.30
8	2.90	2.50	4.20	3.70	3.30	2.40	4.30	1.20	.60	.75	1.00	3.05
9	3.50	2.50	4.00	3.80	3.25	2.40	3.30	1.20	.55	.75	1.15	2.90
10	3.70	3.80	4.30	4.10	3.10	2.40	2.70	1.15	.55	.70	1.30	5.20
11	4.00	4.50	4.30	4.20	3.00	2.30	2.50	1.10	.55	.70	2.30	5.50
12	3.60	4.40	4.50	3.80	3.00	2.10	2.40	1.10	.55	.70	2.60	5.10
13	3.30	4.75	4.30	3.60	2.90	2.00	2.20	1.05	.55	.70	2.20	4.90
14	3.10	4.60	4.50	3.40	2.80	1.90	2.00	1.05	.55	.75	2.00	3.50
15	3.00	4.40	4.40	3.30	2.75	1.90	1.90	1.00	.50	.75	1.80	3.30
16	2.90	4.70	4.20	3.20	2.60	1.80	1.85	.95	.50	.75	1.70	3.00
17	2.80	5.60	4.20	3.00	2.50	1.80	1.85	.95	.50	.75	1.60	2.60
18	2.60	7.00	4.10	3.00	2.50	1.80	1.80	.90	.50	.75	1.60	2.10
19	2.40	7.70	4.00	3.00	2.40	1.60	1.80	.85	.55	.75	2.10	2.10
20	2.20	7.50	3.80	3.20	2.60	1.60	1.70	.85	.56	.75	2.70	2.30
21	2.15	7.00	3.70	3.30	2.80	1.60	1.65	.80	.56	.75	2.65	2.30
22	2.10	6.30	3.60	3.60	3.70	1.50	1.50	.75	.56	.75	2.45	2.30
23	2.10	5.60	3.60	3.60	5.90	1.50	1.50	.70	.55	.75	2.20	2.3
24	2.05	5.30	3.60	3.40	6.40	1.50	1.45	.70	.55	.75	2.10	2.30
25	2.00	5.10	3.50	3.30	6.30	1.40	1.45	.70	.60	.75	1.80	2.30
26	1.90	5.00	3.50	3.10	5.40	1.40	1.40	.70	.60	.75	1.80	2.70
27	1.80	5.80	3.40	3.00	4.60	1.40	1.40	.70	.60	.80	1.70	4.60
28	1.75	6.00	3.30	2.90	4.00	1.40	1.40	.70	.60	.85	1.70	4.40
29	1.70	.....	3.10	2.80	3.70	1.40	1.40	.65	.65	.80	1.70	4.10
30	1.60	.....	3.10	2.80	3.40	1.40	1.30	.65	.70	.75	1.60	3.90
31	1.60	.....	3.00	.....	3.30	.....	1.25	.65	.....	.75	.....	3.70

Rating table for Palouse River near Hooper, Wash., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.6	63	2.2	150	3.8	535	6.0	1,835
.8	69	2.4	175	4.0	625	6.5	2,150
1.0	75	2.6	205	4.2	725	7.0	2,465
1.2	85	2.8	240	4.4	835	7.5	2,780
1.4	95	3.0	280	4.6	953	8.0	3,095
1.6	106	3.2	325	4.8	1,079		
1.8	118	3.4	380	5.0	1,205		
2.0	130	3.6	455	5.5	1,520		

Estimated monthly discharge of Palouse River near Hooper, Wash.

[Drainage area, 2,210 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches
1902.						
January	625	106	216	13,281	0.10	0.12
February	2,906	100	1,088	60,424	.49	.51
March	1,709	280	716	44,025	.32	.37
April	725	240	370	22,076	.17	.19
May	2,087	175	515	31,666	.23	.27
June	325	95	150	8,926	.07	.08
July	1,142	87	178	10,945	.08	.09
August	85	64	75	4,612	.03	.03
September	66	60	62	3,689	.03	.03
October	70	66	67	4,181	.03	.03
November	220	67	118	7,081	.05	.06
December	1,520	106	452	27,792	.20	.23
The year	2,906	60	334	238,698	.15	2.01

WEISER RIVER NEAR WEISER, IDAHO.

The drainage basin of this river is mountainous and rocky, in contrast to the well-wooded areas of the Boise and Payette basins, and the effect is shown in the high flood discharges and low summer flow. A number of small ditches utilize considerable water from this river, but the principal canal is the Galloway canal, which irrigates lands north of Weiser. Above this canal is a bench country susceptible of cultivation if water could be brought to it. The gaging station, established December 6, 1894, is located in the canyon of the river, about 10

miles from Weiser. The gage rod which was set in 1898 was covered during the process of grading for the roadbed of the new Pacific and Idaho Northern Railroad, a line intended to run from Weiser to the mining country in the mountainous district to the north. The new gage, located on October 31, 1899, 100 feet above the old one, is inclined and bolted to a rock bluff; 1.15 feet along the gage equals one foot in elevation. The bench mark consists of a cross cut in the top of the lava rim rock above the gage, and is at an elevation of 12.90 feet. The elevation of the zero of the gage taken from the levels of the railroad is 2,191.34 feet above sea level. Discharge measurements are made from a cable and car about 300 feet below the gage. Both banks are high and not liable to overflow. The bed of the river is of gravel and not likely to change.

The following discharge measurements were made during 1902:

June 26: Gage height, 2.20 feet; discharge, 871 second-feet.
July 19: Gage height, 1.20 feet; discharge, 310 second-feet
August 4: Gage height, 0.40 foot; discharge, 53 second-feet.
September 18: Gage height, 0.30 foot; discharge, 56 second-feet.

Daily gage height, in feet, of Weiser River near Weiser, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.20	1.20	4.80	1.95	3.15	3.90	1.80	0.50	0.25	0.50	0.80	1.5[illegible]
2	1.20	1.15	4.30	2.00	3.10	3.80	1.70	.45	.25	.50	.80	1.5[illegible]
3	1.20	1.10	4.00	2.20	3.00	3.50	1.60	.40	.25	.50	.80	1.5[illegible]
4	1.35	1.10	3.80	2.40	2.85	3.30	1.50	.40	.25	.50	.80	1.5[illegible]
5	1.35	1.30	3.55	2.50	2.75	3.20	1.70	.40	.25	.50	.85	1.5[illegible]
6	1.45	1.60	3.40	2.70	2.80	3.20	1.90	.35	.25	.55	.85	1.5[illegible]
7	1.65	2.00	3.20	2.90	2.95	3.20	2.10	.35	.20	.55	.90	2.5[illegible]
8	1.80	2.60	3.10	3.60	3.60	3.30	2.10	.35	.20	.55	1.00	2.5[illegible]
9	1.75	5.60	3.10	3.90	3.65	3.40	2.00	.30	.20	.55	1.10	2.[illegible]
10	1.70	7.40	3.00	3.20	4.45	3.70	1.90	.30	.25	.55	1.10	2.[illegible]
11	1.65	7.40	2.90	3.00	4.10	3.60	1.80	.25	.30	.60	1.10	3.3[illegible]
12	1.60	4.50	2.80	3.00	4.15	3.50	1.70	.20	.25	.60	1.10	3.[illegible]
13	1.55	3.80	2.60	2.90	4.20	3.40	1.65	.20	.25	.60	1.10	3.[illegible]
14	1.50	3.30	2.55	3.00	4.35	3.30	1.60	.20	.25	.60	1.15	2.[illegible]
15	1.45	4.30	2.50	3.20	4.30	3.00	1.50	.25	.25	.60	1.15	2.7[illegible]
16	1.40	4.30	2.50	3.80	4.25	2.90	1.40	.40	.30	.60	1.15	2.5[illegible]
17	1.40	4.35	2.45	3.45	4.00	2.80	1.30	.45	.30	.60	1.20	2.[illegible]
18	1.35	4.40	2.40	3.50	3.90	2.60	1.30	.65	.30	.60	1.20	1.9[illegible]
19	1.30	3.90	2.30	3.85	3.50	2.50	1.20	.60	.30	.60	1.20	1.[illegible]
20	1.30	3.85	2.20	4.20	3.20	2.50	1.15	.55	.35	.60	1.20	1.7[illegible]
21	1.25	3.55	2.20	4.00	3.10	2.40	1.10	.50	.35	.65	1.20	1.[illegible]
22	1.20	3.30	2.25	3.80	3.20	2.40	1.00	.50	.35	.65	1.20	1.[illegible]
23	1.20	3.25	2.30	3.80	3.20	2.30	.90	.50	.40	.65	1.20	1.5[illegible]
24	1.20	5.40	2.30	3.70	3.10	2.20	.85	.45	.40	.70	1.20	1.[illegible]
25	1.35	7.30	2.25	3.60	3.20	2.10	.80	.40	.40	.70	1.20	2.[illegible]
26	1.35	7.20	2.25	3.50	3.30	2.10	.80	.40	.45	.70	1.20	2.3[illegible]
27	1.45	6.00	2.20	3.40	3.60	2.05	.75	.35	.50	.75	1.20	3.[illegible]
28	1.65	5.90	2.20	3.00	4.10	2.00	.70	.30	.50	.75	1.20	2.8[illegible]
29	1.50	.....	2.10	3.00	4.20	1.90	.65	.30	.50	.75	1.20	2.7[illegible]
30	1.40	.....	2.00	3.10	4.10	1.85	.60	.25	.50	.80	1.20	2.5[illegible]
31	1.30	.....	2.10	.....	4.00	.....	.55	.25	.....	.80	.....	2.4[illegible]

Rating table for Weiser River near Weiser, Idaho, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	39	2.0	720	3.8	2,585	5.6	5,015
.4	71	2.2	875	4.0	2,855	5.8	5,285
.6	105	2.4	1,050	4.2	3,125	6.0	5,555
.8	150	2.6	1,235	4.4	3,395	6.2	5,825
1.0	215	2.8	1,425	4.6	3,665	6.4	6,095
1.2	290	3.0	1,625	4.8	3,935	6.6	6,365
1.4	375	3.2	1,840	5.0	4,205	6.8	6,635
1.6	470	3.4	2,075	5.2	4,475	7.0	6,900
1.8	585	3.6	2,325	5.4	4,745	7.2	7,170

Estimated monthly discharge of Weiser River near Weiser, Idaho.

[Drainage area, 1,670 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	585	290	388	23,857	0.23	0.27
February	7,340	250	3,086	171,388	1.85	1.93
March	3,935	720	1,456	89,526	.87	1.00
April	3,125	685	1,886	112,225	1.13	1.26
May	3,463	1,378	2,354	144,742	1.41	1.63
June	2,720	618	1,546	91,993	.93	1.04
July	795	96	384	23,611	.23	.27
August	115	39	68	4,181	.04	.05
September	87	39	58	3,451	.03	.03
October	150	87	110	6,764	.07	.08
November	290	150	248	14,757	.15	.17
December	2,075	290	918	56,446	.55	.63
The year	7,340	39	1,042	742,941	.62	8.36

BOISE RIVER NEAR BOISE, IDAHO.

The station, established December 15, 1894, is located about 9 miles above Boise, Idaho, at the mouth of the canyon. The original gage was in two sections: The lower part is of 2 by 6 inch plank, inclined, and marked from 1 foot to 7.5 feet; the upper part is a 4 by 4 inch timber, placed vertically, and marked from 7.5 to 12 feet, both portions painted white. The bench mark for it was a bridge spike driven into a cottonwood tree 20 feet from gage and 20 feet from river. It is

3.4 feet above the 8-foot mark on the gage. Measurements are made from a cable just below the gage.

In the latter part of July, 1895, it was decided to locate a secondary gage on Boise River to obtain the slope of the water surface. This was placed 425 feet below the old gage and carefully connected by means of a wye level. Both were referred to the same datum. At that time the lower end of the old gage was found to be warped and was corrected. A gage was also placed on the lower Boise in order to determine the water going by at the lowest stage during the irrigating season. The meter can generally be used by wading, but in high water measurements can be made from a wagon bridge.

April 18, 1897, the river cut into the right bank of the station, carrying out the cable and leaving the gage on a small island, so that the record after that date is unreliable. A temporary gage was therefore established May 12 at the Broadway Bridge, at Boise, and a record kept by it until June 17, when a new gage, which is now used, was again placed in the canyon 1 mile above the old location. The inclined rod is firmly attached to a cottonwood tree. The bench mark is a 20-penny spike in the upstream face of the 6 by 8 cable support, about 2 feet above the ground. Its elevation is 15 feet above datum. Two spikes in same post are 14 feet above datum. Discharge measurements are made from a cable and car 50 feet below the gage. An auxiliary cable for flood measurements is placed 117 feet above the main cable. At ordinary stages the channel is straight, both above and below the station. The banks are high and not liable to overflow. About 300 feet below the cable is a gravel bar, reducing the width of the river at low water to about one-third of the channel and forcing the entire flow against the south bank. The channel is liable to change during extreme high floods. During 1900 the New York Canal Company built a wing dam of timber and loose rock, headed about 150 feet below the station and extending from the north bank diagonally down and across the stream a distance of about 50 feet, in order to protect the north bank from erosion. The construction of this wing dam did not seem to interfere with the flow of the river at the station. During the year new cable supports were set and bench marks were carefully verified.

Discharge measurements of Boise River near Boise, Idaho.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet*
July 11	N. S. Dils	1.80	1,808
July 25	do	1.10	1,346
August 7	do	.70	899
August 13	do	.60	845
September 15	do	.33	610

Daily gage height, in feet, of Boise River near Boise, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.00	1.20	1.70	1.35	3.20	4.70	2.25	0.90	0.45	0.45	0.50	0.80
2	1.20	1.30	1.60	1.85	3.10	4.30	2.35	.80	.45	.45	.50	.80
3	1.10	1.30	1.50	1.98	2.90	4.00	2.30	.70	.40	.42	.50	.90
4	1.03	1.40	1.45	2.40	2.90	3.90	2.55	.70	.40	.42	.50	.95
5	.95	1.30	1.40	2.40	2.90	3.85	2.20	.60	.35	.40	.55	.80
6	1.00	1.30	1.40	2.40	3.10	3.80	2.10	.70	.35	.40	.60	.80
7	1.00	1.25	1.40	3.00	3.30	3.85	2.00	.70	.33	.40	.70	.80
8	1.03	1.80	1.40	3.40	4.30	4.15	1.90	.60	.30	.40	.82	.80
9	1.00	2.00	1.40	2.80	4.60	4.55	1.90	.12	.30	.40	.85	.90
10	.90	2.00	1.38	2.50	4.40	4.90	1.95	.20	.35	.40	.85	1.20
11	.70	1.90	1.38	2.50	4.40	4.80	1.95	.30	.40	.40	.90	1.22
12	.65	1.80	1.35	2.55	4.60	4.60	2.00	.60	.35	.40	.90	1.10
13	.60	1.55	1.35	2.55	5.00	4.45	2.05	.65	.30	.40	.85	.85
14	.70	1.30	1.30	2.50	5.00	4.20	1.95	.67	.35	.40	.80	.60
15	.70	1.25	1.30	2.60	4.70	3.90	1.90	.68	.40	.40	.70	.40
16	.85	1.20	1.30	3.20	4.70	3.50	1.85	.65	.35	.40	.60	.40
17	.95	1.30	1.30	3.40	4.60	3.40	1.80	.60	.30	.40	.70	.40
18	1.00	1.40	1.30	4.00	4.20	3.30	1.70	.60	.35	.40	.80	.48
19	.95	1.35	1.30	4.20	4.00	3.30	1.70	.60	.40	.40	.80	.90
20	.90	1.30	1.30	4.40	3.85	3.20	1.60	.55	.40	.40	.70	.95
21	.85	1.20	1.40	4.00	3.70	3.10	1.50	.55	.40	.40	.65	.98
22	.80	1.20	1.40	3.80	3.65	3.10	1.30	.52	.40	.45	.60	1.00
23	.70	1.20	1.40	3.60	3.60	3.10	1.10	.50	.40	.50	.65	1.10
24	.60	2.70	1.40	3.40	3.55	3.20	1.10	.50	.40	.60	.70	1.10
25	.60	2.40	1.40	3.25	3.65	3.10	1.10	.50	.40	.70	.75	1.20
26	.60	2.20	1.40	3.30	4.00	2.90	1.00	.45	.40	.70	.80	1.15
27	.60	2.10	1.45	3.30	4.40	2.80	1.00	.45	.40	.65	.90	1.20
28	.50	1.80	1.40	3.20	4.90	2.60	1.00	.45	.40	.60	.70	1.00
29	.40	.....	1.40	3.10	5.20	2.55	1.00	.40	.40	.55	.70	.90
30	.60	.....	1.40	3.20	5.10	2.45	1.00	.40	.45	.50	.75	.40
31	1.00	.....	1.40	.....	5.00	.....	.90	.42	.....	.50	.....	.85

Rating table for Boise River at Boise, Idaho, for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	575	1.6	1,610	3.0	3,365	4.4	6,396
.4	695	1.8	1,800	3.2	3,740	4.6	6,844
.6	830	2.0	2,000	3.4	4,156	4.8	7,292
.8	970	2.2	2,220	3.6	4,604	5.0	7,740
1.0	1,115	2.4	2,460	3.8	5,052	5.2	8,188
1.2	1,270	2.6	2,730	4.0	5,500		
1.4	1,435	2.8	3,030	4.2	5,948		

Estimated monthly discharge of Boise River near Boise, Idaho.

[Drainage area, 2,450 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	1,270	695	989	60,811	0.40	[illegible]
February	2,880	1,270	1,615	89,692	.66	[illegible]
March	1,705	1,350	1,433	88,112	.58	[illegible]
April	6,396	1,392	3,559	211,775	1.45	[illegible]
May	8,188	3,190	5,701	350,541	2.33	[illegible]
June	7,516	2,528	4,786	284,787	1.95	[illegible]
July	2,662	1,040	1,721	105,820	.70	[illegible]
August	1,040	530	798	49,067	.33	[illegible]
September	728	635	682	40,582	.28	[illegible]
October	900	695	735	45,193	.30	[illegible]
November	1,040	760	907	53,970	.37	[illegible]
December	1,270	695	1,024	62,963	.42	[illegible]
The year	8,188	530	1,996	1,443,313	.81	11.0[illegible]

SEEPAGE MEASUREMENTS IN BOISE VALLEY.

A series of measurements of the discharge of canals taking water from Boise River between Boise and Caldwell, Idaho, was made during August 11 to 15, 1902, by N. S. Dils, to determine the amount of seepage water returning to the river. These measurements were similar to those made in 1898, 1899, 1900, 1901, and which are published in the reports for those years.

Miscellaneous discharge measurements of Boise River and other streams in Boise Valley.

Date.	Stream.	Locality of heading or place of measurement.	Discharge.
1902.			*Sec.-feet.*
Aug. 11	Sebree canal	North side in Caldwell Canyon	0.0
11	Seibenberg Slough	do	.5
11	Boise River	Caldwell bridge	.7
11	Riverside canal	South side in Caldwell Canyon	23.5
11	Wastein Tenmile Creek	South side below Star	1.0
11	Strahorn canal	do	18.0
11	Boise River	Star bridge	21.6
12	Eureka canal	South side below Soldiers' Home	8.5
12	Phyllis canal	do	15.8
12	Settlers canal	South side above Soldiers' Home	114.3
12	Davis canal	do	30.8
12	McCarty canal	do	103.0
13	Jacobs canal	North side above Soldiers' Home	61.2
13	Ellis canal	do	12.1
13	Goodwin Mill or Penault canal	do	91.5
13	Boise River	At regular gaging station, near Boise	845.0
13	New York canal	South side at gaging station	79.5
13	Costin canal	South side above Soldiers' Home	3.0
13	Lamburger & Ryan	do	.8
13	Ridenbaugh canal	do	433.7
13	Paynne canal	do	11.1
13	Rossi Logging canal	do	118.0
13	Small ditch	do	1.1
13	Rossi waste	do	101.0
13	Electric Light Works waste	do	25.0
14	Waste Car Line Power House	North side above Soldiers' Home	39.7
14	Farmers' Union and Boise Valley canals.	North side at Soldiers' Home	93.3
14	Waste ditch	North side above Star	3.6
14	Waste in sand draw	do	1.0
14	Union canal	do	15.0
14	Dry Creek canal	do	14.8
14	Conway & Akin, 2 ditches	Eagle Island	12.0
14	Catlin & Macey, 2 ditches	do	6.5
14	Davis & Hart	do	14.0
14	Midleton Mill Slough	North side above Star	5.4
14	Midleton Canal Company canal	do	8.5
14	Pioneer canal	do	9.3
15	Midleton Water Company canal	North side below Star	10.4
15	Waste east of Midleton	do	3.0
15	Waste from Willow Creek	do	.1
15	Sebree River	At Caldwell Canyon, north side	16.0
15	Seibenberg Slough	do	.4
15	Boise River	Caldwell bridge	1.5
15	Riverside canal	At Caldwell Canyon, south side	1.0

Summary of seepage measurements made on Boise River, August 11–15, 1902.

	Visible supply.	Diverted.
	Sec.-feet.	*Sec.-feet.*
Boise River and New York canal at gaging station	924.5	
Diverted by canals, south side, between gaging station and Soldiers' Home		[illegible]
Diverted by canals, north side, between gaging station and Soldiers' Home		[illegible]
Return waste, south side, between gaging station and Soldiers' Home	126.0	
Return waste, north side, between gaging station and Soldiers' Home	39.7	
Total from gaging station to Soldiers' Home	1,090.2	[illegible]
Diverted by canals, south side, between Soldiers' Home and Star		[illegible]
		[illegible]
Return waste, north side, between Soldiers' Home and Star	4.6	
Boise River at Star		[illegible]
Total from gaging station to Star	1,094.8	[illegible]
Gain from gaging station to Star	190.0	
Boise River at Star	21.6	
Diverted by canals, south side, between Star and Caldwell Canyon		[illegible]
Diverted by canals, north side, between Star and Caldwell Canyon		[illegible]
Return waste, south side, between Star and Caldwell Canyon	1.0	
Return waste, north side, between Star and Caldwell Canyon	3.1	
Diverted by canals, south side, at Caldwell Canyon		[illegible]
Diverted by canals, north side, at Caldwell Canyon		[illegible]
Boise River at Caldwell		[illegible]
Total from Star to Caldwell	25.7	[illegible]
Gain from Star to Caldwell	21.6	
Total diverted on south side of river to Caldwell		[illegible]
Total diverted on north side of river to Caldwell		[illegible]
Total waste on south side of river to Caldwell	127.0	
Total waste on north side of river to Caldwell	47.4	
Boise River and New York canal at gaging station	924.5	
Boise River at Caldwell		[illegible]
Total from gaging station to Caldwell	1,098.9	[illegible]
Gain from gaging station to Caldwell	211.6	

BRUNEAU RIVER NEAR GRANDVIEW, IDAHO.

Systematic measurements on this river have been maintained immediately below the headworks of the canal system of the Owyhee Land and Irrigation Company, 10 miles east of Grandview, Idaho. There are two gages, one on the north and one on the south side of the river, each at the same elevation. The channel is straight, both above and below the station, the banks high and rocky, and the bed changing little, if any, the section being a good one with the exception that the velocity is very slight at low water.

Daily gage height, in feet, of Bruneau River near Grandview, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.65	1.45	1.75	1.75	2.50	3.90	2.20	1.50	1.25	1.55	1.70	1.75
2	1.65	1.45	1.75	1.75	2.50	3.90	2.20	1.50	1.25	1.50	1.75	1.80
3	1.65	1.45	1.75	1.75	2.50	3.75	2.20	1.45	1.25	1.50	1.75	1.80
4	1.65	1.45	1.75	1.80	2.45	3.70	2.20	1.45	1.30	1.50	1.75	1.85
5	1.70	1.50	1.75	1.85	2.40	3.55	2.15	1.45	1.30	1.50	1.75	1.85
6	1.70	1.55	1.70	1.90	2.35	3.45	2.15	1.45	1.30	1.50	1.75	1.85
7	1.70	1.60	1.70	2.00	2.35	3.35	2.10	1.45	1.30	1.50	1.75	1.90
8	1.70	1.65	1.75	2.15	2.35	3.40	2.50	1.40	1.34	1.50	1.75	1.90
9	1.70	1.70	1.70	2.70	2.70	3.45	2.00	1.40	1.30	1.50	1.80	1.90
10	1.65	1.70	1.70	2.75	2.80	3.50	1.95	1.35	1.30	1.55	1.80	1.90
11	1.65	1.70	1.70	2.60	3.55	3.60	1.40	1.35	1.30	1.55	1.80	1.90
12	1.60	1.70	1.70	2.30	3.35	3.75	1.25	1.35	1.30	1.50	1.80	1.95
13	1.60	1.65	1.70	2.35	3.30	3.65	1.80	1.35	1.30	1.50	1.80	1.95
14	1.60	1.65	1.70	2.40	3.35	3.50	1.80	1.35	1.30	1.50	1.80	1.85
15	1.55	1.70	1.75	2.40	3.45	3.40	1.80	1.30	1.30	1.55	1.80	1.85
16	1.55	1.70	1.75	2.35	3.40	3.25	1.80	1.30	1.30	1.55	1.80	1.75
17	1.55	1.70	1.75	2.40	3.35	3.15	1.80	1.30	1.35	1.55	1.80	1.75
18	1.60	1.70	1.75	2.65	3.25	3.00	1.80	1.30	1.40	1.55	1.85	1.75
19	1.60	1.70	1.75	2.75	3.20	2.90	1.75	1.30	1.40	1.55	1.85	1.75
20	1.60	1.70	1.70	3.00	3.10	2.90	1.70	1.25	1.45	1.55	1.85	1.75
21	1.60	1.70	1.70	3.20	3.00	2.70	1.70	1.25	1.55	1.60	1.85	1.75
22	1.60	1.70	1.70	3.10	3.00	2.60	1.70	1.25	1.50	1.60	1.80	1.75
23	1.60	1.75	1.75	2.90	2.95	2.55	1.70	1.25	1.55	1.65	1.80	1.75
24	1.60	1.75	1.75	2.75	2.90	2.55	1.65	1.25	1.55	1.65	1.80	1.75
25	1.60	1.80	1.75	2.60	2.90	2.50	1.60	1.25	1.55	1.65	1.75	1.75
26	1.53	1.80	1.75	2.55	2.90	2.45	1.55	1.25	1.55	1.70	1.75	1.90
27	1.50	1.80	1.75	2.50	3.00	2.45	1.50	1.25	1.60	1.70	1.75	1.90
28	1.45	1.80	1.75	2.55	3.15	2.40	1.50	1.25	1.55	1.70	1.75	1.85
29	1.45	.....	1.75	2.50	3.35	2.40	1.50	1.25	1.55	1.70	1.75	1.85
30	1.45	.....	1.75	2.50	3.55	2.35	1.50	1.25	1.55	1.70	1.75	1.75
31	1.45	.....	1.75	.....	3.70	.....	1.50	1.25	.....	1.70	.....	1.70

SNAKE RIVER AT MONTGOMERY FERRY, IDAHO.

Ten miles above the gaging station at Montgomery Ferry occurs a natural dam site, from which, as a starting point, surveys for canal lines have been run, covering the large extent of level country susceptible of irrigation on both sides of the river. Measurements at Montgomery Ferry show the amount of water available for irrigation purposes there, and also the amount that could be developed for power purposes at Shoshone Falls, about 45 miles below. The station, established August 5, 1895, is located at Montgomery Ferry, on the stage road from Minidoka to Albion. The gage is inclined and fastened to posts set in the ground. The bench mark is the head of a spike in the east post of the tool house, 1.2 feet above the ground and 52 feet west of the gage. Its elevation is 17.50 feet above gage datum. The letters "B. M." are marked in black paint on the post. The river is 800 feet wide at this section, with a hard gravel bottom not subject to change. When the station was visited by N. S. Dils on

October 14, 1899, a comparison was made of the gage rod with the bench mark, and it was found that the rod had moved to a considerable extent, due to the action of the quicksand on the inclined portion of the rod. The heights as recorded by the observer, as well as the discharge measurements, were corrected. The rod is inclined from zero to 6.5 feet, and is vertical above this latter elevation. The lower portion is fastened at various intervals to posts driven into the ground. Gage readings were not taken during 1900.

The station was reestablished May 1, 1901, and the gage read morning and evening for the remainder of the year. Part of the inclined gage rod which had been moved by quicksand was corrected August 9, 1901, and all previous gage readings were carefully adjusted to correspond with the present position of the rod.

The following discharge measurements were made during 1902:

September 8: Gage height, 1.00 foot; discharge, 2,333 second-feet.
October 27: Gage height, 2.20 feet; discharge, 4,229 second-feet.

Daily gage height, in feet, of Snake River at Montgomery Ferry, near Minidoka, Idaho.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.80	2.40	2.80	2.10	3.45	7.05	4.90	1.90	0.90	1.80	2.40	[illegible]
2	4.20	2.30	2.80	2.10	3.50	7.50	4.75	1.75	.90	1.90	2.40	[illegible]
3	3.80	2.30	2.70	2.10	3.60	7.00	4.70	1.60	.90	1.90	2.40	[illegible]
4	3.40	2.30	2.70	2.10	3.60	8.00	4.60	1.45	.90	1.90	2.40	[illegible]
5	3.20	2.40	2.70	2.10	3.60	7.60	4.60	1.30	1.00	1.90	2.40	[illegible]
6	2.90	2.55	2.60	2.10	3.60	7.15	4.60	1.20	1.00	1.90	2.40	[illegible]
7	2.40	2.85	2.50	2.20	3.60	6.75	4.70	1.10	.90	1.90	2.50	[illegible]
8	2.40	2.90	2.50	2.30	3.50	6.60	4.70	1.05	1.00	1.90	2.60	[illegible]
9	2.40	3.60	2.50	2.40	3.60	6.60	4.55	1.00	1.00	2.00	2.60	[illegible]
10	2.40	3.65	2.50	2.50	3.70	6.50	4.35	.90	1.00	2.00	2.60	[illegible]
11	2.40	3.90	2.40	2.60	4.00	6.65	4.10	.90	1.00	2.00	2.70	[illegible]
12	2.40	3.10	2.40	2.60	4.60	7.15	3.95	.90	1.00	2.00	2.80	[illegible]
13	2.40	2.70	2.40	2.60	5.10	7.60	3.75	.90	1.00	2.00	2.80	[illegible]
14	2.40	2.70	2.40	2.50	5.50	7.90	3.55	.90	1.10	2.00	2.80	[illegible]
15	2.30	2.70	2.40	2.40	5.85	7.95	3.35	.85	1.10	2.10	2.90	[illegible]
16	2.20	2.70	2.30	2.40	6.00	7.90	3.30	.80	1.10	2.10	2.90	[illegible]
17	2.20	2.70	2.30	2.30	6.45	8.00	3.20	.85	1.20	2.10	2.90	[illegible]
18	2.20	2.70	2.30	2.30	6.50	7.65	3.15	.90	1.20	2.20	2.90	[illegible]
19	2.20	2.70	2.30	2.20	6.90	7.35	3.15	.90	1.20	2.20	2.90	[illegible]
20	2.20	2.70	2.30	2.40	6.90	7.10	3.15	.90	1.30	2.20	2.90	[illegible]
21	2.20	2.70	2.20	2.55	6.40	6.95	2.95	.90	1.40	2.20	2.80	[illegible]
22	2.30	2.70	2.20	3.00	6.15	6.50	2.80	.90	1.30	2.20	2.80	[illegible]
23	2.30	2.70	2.30	3.35	5.85	5.95	2.65	.90	1.30	2.20	2.80	[illegible]
24	2.30	2.70	2.30	3.55	5.55	5.40	2.45	.90	1.40	2.20	2.70	[illegible]
25	2.40	2.60	2.30	3.60	5.45	5.15	2.35	.90	1.40	2.20	2.60	[illegible]
26	3.00	2.60	2.20	3.50	5.25	5.15	2.25	.90	1.60	2.20	2.50	[illegible]
27	3.10	2.80	2.20	3.45	5.30	5.20	2.15	.90	1.50	2.20	2.60	[illegible]
28	3.30	2.80	2.20	3.40	5.40	5.20	2.10	.90	1.60	2.20	2.70	[illegible]
29	3.00	.....	2.20	3.30	5.75	5.15	2.10	.90	1.70	2.30	2.75	[illegible]
30	2.70	.....	2.20	3.30	6.25	4.95	2.00	.90	1.80	2.30	2.90	[illegible]
31	2.40	.....	2.10	.....	6.70	.....	1.95	.90	.....	2.30	.....	[illegible]

SNAKE RIVER (NORTH FORK) NEAR ORA, IDAHO.

This station was established August 20, 1902, by N. S. Dils. It is located at the North Fork Bridge 2 miles south of Ora and 10 miles above St. Anthony, Idaho. A temporary vertical gage was set on the lower side of the first pier from the north shore, at which point the permanent gage will be located. The observer is Mrs. Martha J. Fritz. The initial point for soundings is a bolt through the toe of the cantilever on the north end of the lower side of the bridge. The bridge is 210 feet from toe to toe of cantilever. It consists of four spans resting on three rock-filled crib piers. Measurements are made from the lower side of this bridge. The channel is straight both above and below this station. The banks are high and do not overflow. The bed of the stream is hard gravel, quite smooth, and not liable to change.

The following discharge measurements were made during 1902:

August 20: Gage height, 2.00 feet; discharge, 1,241 second-feet.
September 29: Gage height, 2.00 feet; discharge 1,244 second-feet.

Daily gage height, in feet, of Snake River (North Fork) near Ora, Idaho.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1		2.00	2.00	2.10	1.90	17		2.00	2.00	2.10	1.90
2		2.00	2.00	2.00	1.90	18		2.00	2.00	2.10	1.90
3		2.00	2.00	2.00	1.90	19		2.00	2.00	2.00	1.10
4		2.00	2.00	2.00	1.90	20	2.00	2.00	2.00	1.90	2.00
5		2.00	2.00	2.00	1.90	21	2.00	2.00	2.00	1.90	2.00
6		2.00	2.00	2.00	1.90	22	2.00	2.00	2.00	1.90	2.00
7		2.00	2.00	2.00	1.90	23	2.00	2.00	2.00	1.90	2.00
8		2.00	2.00	2.00	1.90	24	2.00	2.00	2.00	1.90	2.00
9		2.00	2.00	2.00	2.00	25	2.00	2.00	2.00	1.90	2.00
10		2.00	2.00	2.00	2.00	26	2.00	2.00	2.00	1.90	2.00
11		2.00	2.00	2.00	2.00	27	2.00	2.00	2.00	1.90	2.00
12		2.00	2.00	2.10	2.00	28	2.00	2.00	2.00	1.90	2.00
13		2.00	2.00	2.10	2.00	29	2.00	2.00	2.10	1.90	2.00
14		1.90	2.00	2.10	2.00	30	2.00	2.00	2.10	1.90	2.00
15		2.00	2.00	2.10	2.00	31	2.00		2.10		2.00
16		2.00	2.00	2.10	2.00						

FALL RIVER AT WILSON'S MILL, NEAR MARYSVILLE, IDAHO.

This station was established August 21, 1902, by N. S. Dils. It is located at P. Wilson's sawmill, 12 miles southeast of Marysville, Idaho. The gage is a plain staff graduated to feet and tenths and is firmly spiked to the lower side of the first bent from the south shore. It is read by P. Wilson, the owner of the mill. The initial point for soundings is the face of the south abutment and measurements are made from the bridge. The bridge rests on crib abutments. The river is straight both above and below the station. The banks are high and not liable to overflow. The bed of the river is hard gravel

with occasional lava bowlders. George Harringfield, a local civil engineer, states that the river in this vicinity has a fall of from 37½ to 39 feet per mile. The Harringfield canal is being built to divert the water from above this station.

The following discharge measurements were made during 1902:

August 21: Gage height, 2.00 feet; discharge, 916 second-feet.
October 1: Gage height, 1.90 feet; discharge, 857 second-feet.

Daily gage height, in feet, of Fall River near Marysville, Idaho.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.						1902.					
1	.....	1.90	1.90	1.80	1.80	17	.....	1.90	1.80	1.80	1.80
2	.....	1.90	1.90	1.80	1.80	18	.....	1.90	1.80	1.80	1.80
3	.....	1.90	1.90	1.80	1.80	19	.....	1.90	1.80	1.80	1.80
4	.....	1.90	1.90	1.80	1.80	20	.....	1.90	1.80	1.80	1.80
5	.....	2.00	1.90	1.80	1.80	21	.....	1.90	1.80	1.80	1.80
6	.....	2.00	1.90	1.80	1.80	22	.....	1.90	1.80	1.80	1.80
7	.....	1.90	1.90	1.80	1.80	23	.....	1.90	1.80	1.80	1.80
8	.....	1.90	1.90	1.80	1.80	24	2.00	1.90	1.80	1.80	1.80
9	.....	1.90	1.90	1.80	1.80	25	2.00	1.90	1.80	1.80	1.80
10	.....	1.90	1.90	1.80	1.80	26	2.00	1.90	1.80	1.80	1.80
11	.....	1.90	1.90	1.80	1.80	27	2.00	1.90	1.80	1.80	1.80
12	.....	1.90	1.90	1.80	1.80	28	2.00	1.90	1.80	1.80	1.80
13	.....	1.90	1.90	1.80	1.80	29	2.00	1.90	1.80	1.80	1.80
14	.....	1.90	1.90	1.80	1.80	30	2.00	1.90	1.80	1.80	1.80
15	.....	1.90	1.90	1.80	1.80	31	2.00	.....	1.80	.....	1.80
16	.....	1.90	1.80	1.80	1.80						

Miscellaneous measurements in Columbia River drainage basin.

Date.	Hydrographer.	Stream.	Locality.	Discharge.
1902.				
June 10, 11	N. S. Dils	All of the springs flowing into Snake River.	Between Shoshone Falls and the Cedars.	112
Aug. 7	do	New York canal	Near Boise gaging station	46
13	do	do	do	80
15	do	do	do	Dry
25	do	Snake River	1 mile above mouth of Blackfoot River.	Dry.
27	do	Blue Lakes Creek	At Blue Lakes, Idaho	80
Sept. 1	do	Snake River	Between Shoshone Falls and Twin Falls.	1,987
25	do	Black Springs Creek	Near Ora gaging station	9
Nov. 28	J. S. Baker	Big Blackfoot	Bonner	4.01

PUGET SOUND DRAINAGE BASIN.

For convenience in arrangement the smaller rivers which have their headwaters on the western slope of the Cascade Range and which flow into Puget Sound north of Seattle have been grouped as the Puget Sound drainage. Of these White River has its source near Mount

Rainier and flows into Puget Sound near Seattle, Wash. Cedar River is a tributary of White River. Snoqualmie and Skykomish rivers unite to form the Snohomish, which flows into the Sound about 10 miles beyond the junction near Everett, Wash. The Stillaquamish lies north of the Skykomish and has a parallel course. The following list includes the stations in the Puget Sound drainage basin:

White River at Buckley, Wash.
Cedar River near Maple Valley, Wash.
Cedar River at Cedar Lake, near Northbend, Wash.
Snoqualmie River above Snoqualmie Falls, near Snoqualmie, Wash.
Skykomish River (south fork) near Index, Wash.
Stilaguamish River near Robe, Wash.

WHITE RIVER AT BUCKLEY, WASH.

In order to determine the amount of power that could be developed on White River, a station was established by Sydney Arnold, April 22, 1899, at the new highway bridge, 500 feet above the Northern Pacific Railway bridge, and one-half mile north of the town of Buckley, Wash. The location is in sec. 34, T. 20 N., R. 6 E. of the Willamette meridian. The rod of the wire gage is fastened to the guard rail of the highway bridge. The length of the wire rope is 20 feet. The elevation of the top of the guard rail at the pulley is 19.56 feet above gage datum. The bridge is a clear span of 180 feet, crossing the river a trifle obliquely. The channel is straight for some distance above and below the bridge, but the section is not a very good one, owing to the sudden fall a short distance below. About 300 feet above the bridge is a good section, with fine gravel bottom in calmer water, but in order to utilize it it would be necessary to install a cable. An examination of the river channel for some distance above and below this point was made, but the present location is about the only one available for accurate results.

No measurements of discharge were made at this station during 1902.

Daily gage height, in feet, of White River at Buckley, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1802.												
1	1.15	0.85	1.15	0.80	1.30	1.95	1.95	1.40	0.85	0.70	0.65	4.[illegible]
2	1.20	.85	1.15	.80	1.30	1.80	2.10	1.35	.90	.65	1.15	2.[illegible]
3	1.35	.80	1.10	.95	1.65	1.75	1.90	1.30	1.00	.60	1.48	2.[illegible]
4	2.53	.75	1.10	1.10	1.60	1.70	2.15	1.20	.95	.60	1.15	2.[illegible]
5	2.25	.70	1.15	1.10	1.55	1.60	2.15	1.25	.80	.60	1.05	2.0[illegible]
6	3.30	.70	1.15	1.60	1.70	1.60	1.95	1.30	.90	.55	.85	1.8[illegible]
7	3.35	.70	1.15	1.50	2.05	1.60	1.80	1.45	1.00	.55	1.20	1.65
8	3.70	.75	1.20	1.40	2.15	1.80	1.75	1.45	.90	.60	2.73	2.[illegible]
9	2.85	.85	1.20	1.25	2.15	2.15	1.70	1.35	.85	.60	2.13	3.[illegible]
10	2.35	.85	1.20	1.15	2.55	2.15	1.80	1.20	.75	.60	1.70	2.4
11	2.10	.80	1.40	1.15	2.65	2.10	1.90	1.20	.75	.55	1.80	2.[illegible]
12	1.80	.75	1.35	1.15	2.40	2.05	1.80	1.15	.70	.60	1.65	1.[illegible]
13	1.65	.70	1.30	1.10	2.15	2.00	1.70	1.10	.70	.60	1.40	1.65
14	1.50	.70	1.20	1.10	2.15	2.00	1.70	1.10	.70	.65	1.25	1.65
15	1.45	1.30	1.15	1.05	2.20	1.95	1.80	1.10	.70	.65	1.20	1.5[illegible]
16	1.25	2.80	1.10	1.15	2.20	1.80	1.90	1.10	.65	1.05	1.55	1.4[illegible]
17	1.25	2.60	1.15	1.40	2.35	1.70	1.75	1.05	.65	.80	1.70	1.3[illegible]
18	1.15	2.15	1.10	1.60	2.15	1.70	1.65	.95	.65	.65	1.85	1.25
19	1.15	1.80	1.10	2.15	2.00	1.80	1.65	.95	.85	.65	1.65	1.9[illegible]
20	1.10	1.65	1.10	1.90	1.90	1.95	1.80	1.00	.60	.60	1.40	1.15
21	1.05	1.60	1.05	1.60	1.80	2.15	1.95	1.10	.50	.60	1.25	1.1[illegible]
22	1.00	1.50	1.00	1.55	1.80	2.20	1.85	1.10	.50	.60	1.30	1.1[illegible]
23	.90	1.40	1.00	1.50	1.95	2.35	1.70	1.05	.45	.55	1.30	1.05
24	.85	1.40	.95	1.40	1.95	2.60	1.60	1.00	.80	.55	1.50	1.8[illegible]
25	.65	1.35	.95	1.35	2.05	2.60	1.60	.90	.75	.50	1.30	3.0[illegible]
26	.90	1.30	.95	1.35	2.40	2.35	1.60	.90	.90	.50	1.[illegible]0	3.43
27	.80	1.20	.90	1.35	3.00	2.15	1.50	.90	1.80	.50	1.20	2.6[illegible]
28	.80	1.20	.90	1.35	3.10	1.95	1.45	.85	.95	.75	1.20	2.15
29	.90	.....	.90	1.30	2.75	1.85	1.35	.80	.80	.60	1.15	1.9[illegible]
30	.90	.....	.85	1.30	2.40	1.95	1.30	.75	.90	.75	1.78	1.9[illegible]
31	.90	.....	.85	.....	2.15	.....	1.50	.80	.....	.75	.....	1.90

CEDAR RIVER NEAR MAPLE VALLEY, WASH.

This station is located at the intake of the Seattle waterworks and is 15 miles below Cedar Lake, 4 miles from the Northern Pacific Railway at Ravensdale, and 6 miles from the Columbia and Puget Sound Railway at Maple Valley. The station was established September 27, 1902, by T. A. Noble. The gage is a plain staff graduated to feet and hundredths, to which is attached a hook gage and vernier reading to thousandths. When this gage reads zero the hook is level with the crest of the dam. It is fastened securely to the head gates above the dam, and is read daily by George Landsburg. The bench mark is the crest of the dam. The elevation, from city levels, of the south end is 535.831 feet and of the north end 535.840 feet. The gagings at this station are made at two points. The first is 142 feet below the dam where the cross section is small, the current rapid and suitable for gaging the stream at stages below 1 foot on the gage. The measurements at this point are made from a cable. The initial point for soundings is on the right bank; the channel is straight; the right bank is steep; the left bank has a sloping gravelly beach; and the bed of the stream is rocky. At all stages of the river above 1 foot on the

gage the measurements are made from a cable located 600 feet above the dam, where the cross section is large and suitable for gaging the higher stages of the river. The initial point for soundings is a spike driven into the top of a hemlock stump about 12 inches in diameter near the water. The right bank is a sloping sandy beach; the left bank is steep and of hardpan formation. The bed is permanent—rocky near the right bank and sand and gravel near the left bank.

To the discharge measurements made below the dam should be added the amount of water flowing into the gravity system which supplies the city of Seattle. This varies from 34 to 37 second-feet. The discharge of this pipe line was measured during the winter of 1901–2, by T. A. Noble, and the results have been published in Volume XLIX, page 112, Transactions of the American Society of Civil Engineers.

During 1902 the following discharge measurements were made by T. A. Noble.

September 28: Gage height, 0.88 feet: discharge, 435 second-feet.
October 22: Gage height, 0.38 feet; discharge, 124 second-feet.
November 23: Gage height, 1.31 feet; discharge, 755 second-feet.
December 25: Gage height, 1.74 feet; discharge, 1,043 second-feet.
December 26: Gage height, 2.04 feet; discharge, 1,399 second-feet.

Daily gage height, in feet, of Cedar River near Maple Valley, Wash.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	1.53	0.92	1.35	1.01	1.32	1.56	1.05	0.68	0.47	0.70	0.63	3.28
2	1.49	.92	1.18	1.05	1.39	1.55	1.12	.68	.53	.66	.70	3.08
3	1.45	.90	1.18	1.05	1.68	1.51	1.14	.68	.53	.62	1.12	2.54
4	1.90	.90	1.22	1.05	1.80	1.47	1.30	.66	.53	.58	1.22	2.40
5	1.99	.90	1.30	1.05	1.76	1.39	1.55	.64	.53	.55	1.19	2.20
6	2.36	.95	1.32	1.05	1.72	1.35	1.64	.62	.51	.52	1.10	1.85
7	2.53	.95	1.39	1.07	1.80	1.35	1.68	.60	.51	.51	1.11	1.67
8	2.86	.99	1.39	1.24	1.88	1.32	1.54	.60	.51	.52	1.60	1.47
9	2.61	1.05	1.47	1.30	1.93	1.41	1.53	.58	.51	.50	1.90	1.91
10	2.34	1.01	1.55	1.30	1.93	1.41	1.47	.58	.49	.48	1.83	1.83
11	2.11	.97	1.68	1.26	1.93	1.41	1.39	.58	.49	.47	1.79	1.71
12	1.90	.97	1.68	1.22	1.88	1.39	1.30	.55	.47	.46	1.83	1.58
13	1.78	.97	1.55	1.18	1.84	1.32	1.28	.55	.45	.36	1.72	1.56
14	1.65	.92	1.43	1.05	1.80	1.30	1.14	.53	.45	.36	1.55	1.45
15	1.53	.91	1.35	1.01	1.84	1.22	1.05	.53	.43	.35	1.43	1.37
16	1.40	1.39	1.35	.99	1.82	1.18	1.09	.53	.41	.36	1.42	1.27
17	1.36	1.64	1.30	1.05	1.97	1.18	1.05	.60	.39	.35	1.58	1.22
18	1.28	1.85	1.26	1.39	2.05	1.16	1.01	.58	.37	.40	1.85	1.15
19	1.23	1.80	1.22	1.47	2.01	1.14	.99	.55	.47	.39	1.85	1.61
20	1.11	1.60	1.22	1.55	1.89	1.09	.97	.55	.35	.35	1.69	1.60
21	2.07	1.55	1.22	1.55	1.87	1.14	.93	.55	.33	.35	1.54	1.49
22	2.03	1.51	1.26	1.53	1.84	1.09	.91	.53	.33	.38	1.42	1.73
23	.99	1.43	1.28	1.51	1.76	1.14	.89	.53	.33	.65	1.34	1.30
24	.97	1.35	1.24	1.47	1.80	1.12	.85	.53	.33	.62	1.36	1.36
25	.97	1.30	1.22	1.43	1.72	1.12	.80	.51	.28	.56	1.32	1.66
26	.97	1.30	1.18	1.39	1.68	1.09	.80	.51	.28	.52	1.28	2.03
27	.97	1.35	1.14	1.35	1.66	1.09	.76	.49	1.01	.48	1.25	1.92
28	.95	1.35	1.14	1.30	1.80	1.09	.74	.49	.88	.53	1.24	1.75
29	.95	.....	1.09	1.32	1.88	1.05	.74	.47	.80	.53	1.23	1.69
30	.95	.....	1.05	1.35	1.80	1.12	.72	.47	.70	.53	1.36	1.78
31	.90	.....	1.18	.....	1.72	.....	.70	.47	.....	.61	.....	1.93

CEDAR RIVER AT CEDAR LAKE, NEAR NORTHBEND, WASH.

This station was established October 17, 1902, by T. A. Noble. It is located 9 miles southeast of Northbend, Wash. The gage is a plain staff graduated to feet and tenths. A hook and vernier are used for reading to hundredths. It is securely nailed to a large cedar stump. The bench mark is located on the stump which holds the gage. Its elevation is 1,542.07 feet above the datum of the city of Seattle, Wash. The initial point for soundings is a nail driven into the root of a hemlock stump on the right bank. The gagings are made from a cable. The channel is straight both above and below the station. The right bank is steep, high, and never overflows; the left bank is steep and overflows at extreme high water. The bed of the stream is rocky near the left bank, and of gravel and sand at the right bank. Underlying the bed is a formation of very compact hardpan, which shows no sign of washing away. This formation also underlies the river up to and including the lower portion of Cedar Lake, which is about [illegible] feet upstream from the gaging station. Cedar Lake contains about 1,200 acres at low water.

During 1902 the following discharge measurements were made by T. A. Noble:

October 17: Gage height, 2.21 feet; discharge, 245 second-feet.
October 18: Gage height, 1.70 feet; discharge, 112 second-feet.
October 18: Gage height, 2.17 feet; discharge, 217 second-feet.
October 19: Gage height, 1.13 feet; discharge, 34 second-feet.
October 19: Gage height, 1.49 feet; discharge, 89 second-feet.

Daily gage height, in feet, of Cedar River at Cedar Lake, Washington.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1		2.04	8.65	12		4.61	3.53	23	2.16	3.22	[illegible]
2		2.38	7.60	13		4.30	3.35	24	2.00	3.23	[illegible]
3		3.01	6.35	14		3.87	3.24	25	1.97	3.14	[illegible]
4		3.12	5.58	15		3.56	2.95	26	1.75	3.08	[illegible]
5		2.98	4.94	16		3.60	2.81	27	1.67	3.04	[illegible]
6		2.91	4.31	17	2.21	4.00	2.68	28	1.73	3.01	[illegible]
7		3.06	3.90	18	2.18	4.57	2.59	29	1.70	3.02	[illegible]
8		4.14	3.62	19	1.49	4.44	2.49	30	1.79	3.53	[illegible]
9		4.94	4.00	20		4.03	2.44	31	1.95		[illegible]
10		4.57	4.02	21		3.67	2.37				
11		4.59	3.95	22	2.40	3.41	2.37				

SNOQUALMIE RIVER ABOVE SNOQUALMIE FALLS, WASH.

This station was originally established by T. A. Noble on September 14, 1902. The gage was then located below the falls, but was destroyed by the flood of December 1, 1902. On November 2 another gage was placed about 3 miles above Snoqualmie Falls post-office. The gage consisted of a plain staff graduated to feet and tenths and reading to

hundredths of a foot by means of a hook and vernier. The elevation of the zero on the gage was assumed to be 100 feet. The gage was fastened to an alder tree. January 3, 1903, this gage was washed out and on January 7 was replaced by a gage in two parts, 7 and 8 feet long, respectively. The elevation of the zero of the gage is 100.06 feet. The bench mark is on a large maple stump on the right bank. It consists of a spike driven into the stump about 4 feet from the ground. This is also the initial point for the soundings. The right bank is high and never overflows; the left bank overflows at extreme high water. The bed of the stream is of gravel and sand and is not liable to shift. The station is located below the junction of the North, South, and Middle forks of Snoqualmie River. At Snoqualmie Falls, about 4 miles below this station, the river flows over a precipice 268 feet high. Above the falls the Snoqualmie Falls Power Company has built a dam and water power plant. The slack water from this dam reaches back from the falls about 3 miles and probably affects the flow of the river slightly at the gaging station. This is the only possible location for a gaging station which will include all three forks of the river.

During 1902 the following discharge measurements were made by T. A. Noble:

[a] September 20: Gage height, 1.15 feet; discharge, 727 second-feet.
[a] October 14: Gage height, 1.04 feet; discharge, 641 second-feet.
[b] November 3: Gage height, 5.04 feet; discharge, 3,231 second-feet.
[b] December 14: Gage height, 3.37 feet; discharge, 1,888 second-feet.
[b] December 17: Gage height, 2.76 feet; discharge, 1,384 second-feet.

Daily gage height, in feet, of Snoqualmie River below Snoqualmie Falls, Washington.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.					1902.				
1	.....	1.80	2.45	(c)	12	.....	1.15	3.70	(c)	23	0.97	1.19	2.60	(c)
2	.....	1.60	4.02	.....	13	.....	1.10	3.15	.....	24	1.05	1.08	3.13	.....
3	.....	1.47	3.50	.....	14	0.95	.99	2.73	.....	25	1.39	1.04	2.70	.....
4	.....	1.45	3.00	.....	15	.93	1.09	2.60	.....	26	1.50	1.00	2.63	.....
5	.....	1.35	2.50	.....	16	.92	1.25	4.17	.....	27	3.80	.93	2.65	.....
6	.....	1.25	2.20	.....	17	.92	1.29	4.25	.....	28	2.60	1.62	2.64	.....
7	.....	1.22	2.23	.....	18	.90	1.20	3.85	.....	29	2.05	1.70	2.45	.....
8	.....	1.30	5.05	.....	19	1.50	1.10	3.13	.....	30	2.02	2.41	6.53	.....
9	.....	1.30	3.55	.....	20	1.19	1.10	2.73	.....	31	.....	2.75	.....	.....
10	.....	1.23	3.30	.....	21	1.06	1.08	2.47	.....					
11	.....	1.25	4.55	.....	22	1.00	1.18	2.73	.....					

[a] Below the falls. [b] Above the falls. [c] Gage washed out. Station removed above falls.

Daily gage height, in feet, of Snoqualmie River above Snoqualmie Falls, Washington.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		15.00	12	5.99	3.84	23	3.82	[illegible]
2		7.41	13	4.72	3.80	24	3.23	[illegible]
3	5.23	5.64	14	3.94	3.47	25	3.46	[illegible]
4	4.21	6.46	15	3.46	3.20	26	3.08	[illegible]
5	3.19	5.80	16	4.59	2.98	27	3.19	[illegible]
6	3.20	4.47	17	5.63	2.81	28	3.08	[illegible]
7	3.87	3.93	18	6.20	2.66	29	3.00	[illegible]
8	6.26	3.72	19	4.88	2.50	30	3.23	[illegible]
9	4.94	7.30	20	4.06	2.80	31		[illegible]
10	5.38	5.24	21	3.59	2.90			
11	6.19	4.34	22	3.73	3.01			

SKYKOMISH RIVER (SOUTH FORK) NEAR INDEX, WASH.

This station was established October 6, 1902, by T. A. Noble. It is located about 2 miles above Index and about 300 feet from the railroad track. The gage is a plain staff graduated to feet and tenths. A hook and vernier are used for reading to hundredths of a foot. Readings are made daily by Louis G. Heybrook. The gage is fastened by means of plugs driven in drill holes in the solid rock. The bench mark is a cross cut in the rock about 6 feet above low water and 40 feet downstream from the gage. Its elevation as obtained from the Great Northern Railway is 679.158 feet. The elevation of the zero of the gage is 669.926 feet. The initial point for sounding is on the left bank at a plug driven in the solid rock 10 feet from the edge of stream at low water. The gagings are made from a cable. The channel is straight, both above and below the station. Both banks are of solid rock. The bed of the stream is of sand and gravel, not liable to change except near the left bank, where the sand shifts at high water. This does not cause any important change in the cross section. This station is 300 feet upstream from Sunset Falls, where the river plunges down a solid granite ledge with a slope of about two horizontal to one vertical. The ledge answers the purpose of a spillway in regulating the flow of the river at the gaging station, since the water has a free discharge and a permanent bed just below the station.

Daily gage height, in feet, of Skykomish (South Fork) River near Index, Wash.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	3.65	11.41	12	1.31	5.27	3.53	23	0.88	3.25	2.10
2	.....	4.10	7.28	13	1.23	4.39	3.35	24	.99	3.69	2.50
3	.....	4 70	5.65	14	1.21	3.76	3.10	25	.99	3.53	8.20
4	.....	4.15	5.52	15	1.22	3.57	2.85	26	.91	3.26	8.59
5	.....	3.54	4.82	16	1.31	4.72	2.65	27	.91	3.65	6.36
6	.....	3.02	4.26	17	1.29	5.64	2.49	28	1.31	3.33	5.51
7	1.61	3.92	3.69	18	1.18	6.09	2.38	29	2.51	3.09	4.50
8	1.53	5.65	3.52	19	1.13	4.88	2.29	30	3.42	5.95	5.31
9	1.52	5.21	5.35	20	1.09	4.09	2.30	31	3.92	.....	6.01
10	1.46	4.76	4.55	21	1.07	3.62	2.12				
11	1.39	5.85	4.03	22	.90	3.38	2.14				

Discharge measurements of Skykomish River (South Fork) near Index, Wash.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-feet.*
October 7	T. A. Noble	1.58	685
October 8	do	1.53	657
October 22	A. B. Carter	1.25	565
December 7	T. A. Noble	3.64	1,674
December 8	do	3.72	1,805
December 9	do	5.33	2,850
December 19	do	2.23	946

STILAGUAMISH RIVER NEAR ROBE, WASH.

This station was established December 3, 1902, by T. A. Noble. It is located at the bridge of the Everett and Monte Cristo Railway, 1½ miles east of Robe, Wash. The gage is a plain staff graduated to feet and tenths, and read by means of a hook gage and vernier to hundredths. It is fastened to the east bridge pier, and is read daily by Wm. A. Dobson. Arrangements will be made for gaging the river during the coming summer. The bench mark is the top of the rail above the east pier of the bridge. Its elevation is 901.06 feet above sea level. The elevation of the zero of the gage is 873.184 feet. The elevation of the bridge to which the gage is attached was furnished by the Everett and Monte Cristo Railway Company.

Daily gage height, in feet, of Stilaguamish River near Robe, Wash.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1902.		1902.		1902.		1902.	
1		9	8.40	17	1.56	25	[illegible]
2		10	8.50	18	1.36	26	[illegible]
3	3.54	11	9.10	19	1.40	27	[illegible]
4	3.92	12	8.30	20	2.28	28	[illegible]
5	2.85	13	2.48	21	1.84	29	[illegible]
6	2.30	14	1.07	22	1.96	30	[illegible]
7	3.40	15	1.87	23	1.78	31	[illegible]
8	8.40	16	1.56	24	4.61		

HUDSON BAY DRAINAGE BASIN.

Red River drains a large basin in the United States, covering portions of Minnesota and North and South Dakota, characterized by a level topography, broken up in places by moraines and other glacial deposits. The major part is prairie, and its eastern half has an abundance of lakes and some woods. The main river flows nearly due north, cutting a deep channel in its broad level valley and is subject to sudden rises caused by heavy spring rains, entailing frequently considerable loss of life and property. The valley of Red River comprises about 9,000,000 acres of excellent agricultural lands which to a large extent still await settlement. A number of water powers have been developed during recent years on the tributaries entering from both sides.

Red River drains into Hudson Bay through Lake Winnipeg and Nelson River. Red Lake River, one of its principal tributaries in Minnesota, drains Red Lake in the northern part of the State. Sheyenne River, its principal tributary from North Dakota, joins the Red River about 10 miles below Fargo, N. Dak.

St. Mary River heads in northern Montana, near the Canadian boundary line, on the eastern slope of the main range of the Rocky Mountains, in a region of perpetual snow and in the midst of numerous glaciers. It starts from the great Blackfoot Glacier (probably the largest in the Rocky Mountains within the United States) and receives affluents from at least a dozen lesser ones. These small streams unite within a short distance from their sources and flow into a lake hemmed in by high mountains, known as upper St. Mary Lake. Below this, separated by a narrow strip of land, is lower St. Mary Lake. The aggregate length of these two lakes is about 22 miles. The River flows out of the lower lake, the elevation of which is 4,460 feet above sea level, and within two miles is joined by a stream nearly, if not quite, as large as itself, known as Swiftcurrent Creek, which receives the water of the Grinnell Glacier and four lesser ones. From the confluence of these streams to the boundary of the British possessions, a distance of 12 miles, the river flows in a northerly direction. Enter-

ing Alberta, it empties into Belly River, its waters at length finding their way through Saskatchewan River into Hudson Bay. A canal has been constructed in Canada, by the Canadian Northwest Irrigation Company, which diverts water from the right bank of St. Mary River about 5 miles below the international boundary line.

The following list includes the stations of the Hudson Bay drainage basin:

St. Mary River at international line near Cardston, Alberta.
St. Mary River at Main, Mont.
Swiftcurrent Creek at Henkel's ranch near St. Mary, Mont.
St. Mary River at dam site near St. Mary, Mont.
Red River at Emerson, Manitoba.
Red Lake River at Crookston, Minn.
Red River at Grand Forks, N. Dak.
Sheyenne River at Haggart, N. Dak.
Red River at Fargo, N. Dak.
Devils Lake at Devils Lake, N. Dak

ST. MARY RIVER AT INTERNATIONAL LINE NEAR CARDSTON, ALBERTA.

This station was established October 11, 1902, by C. T. Prall. It is located one-quarter mile north of the Montana line and 17 miles south of Cardston, Alberta. The gage is of the usual wire type with the gage board graduated to feet and tenths. The length from the bottom of the weight to the marker is 10.85 feet. It is fastened to a tree and a post. The initial point for sounding is on the left bank. The channel is straight for 300 feet above and 150 feet below the station. The right bank is high and not liable to overflow. The left bank is sloping and liable to overflow at very high water. The bed of the stream is of sand and gravel, but not liable to scour. The measurements are made from a car and cable. The observer is Vernon Shaw. Bench mark No. 1 is a 60-penny spike driven in a cottonwood tree located directly back of the rod. Its elevation is 12.92 feet above the zero of the gage. Bench mark No. 2 is a 60-penny spike driven in a post 1 foot in diameter and 2 feet high. The post is set in the ground 92 feet northwest of the gage rod. Its elevation is 17.56 feet above the zero of the gage.

The following discharge measurements were made during 1902:

October 11: Gage height, 3.90 feet; discharge, 501 second-feet.
October 23: Gage height, 3.65 feet; discharge, 387 second-feet.

Daily gage height, in feet, of St. Mary River at International line, near Cardston, Alberta.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.				
1	.....	4.00	3.45	3.65	17	4.00	3.95	3.65	[illegible]
2	.....	4.00	3.45	3.60	18	4.00	3.95	3.65	[illegible]
3	4.25	4.05	3.50	3.50	19	4.00	3.90	3.60	[illegible]
4	4.25	4.00	3.50	3.30	20	4.00	3.90	3.65	[illegible]
5	4.20	.....	3.50	3.60	21	4.10	3.90	3.65	[illegible]
6	4.10	.....	3.45	3.80	22	4.10	3.90	3.65	[illegible]
7	4.12	.....	3.45	3.80	23	4.00	3.65	3.65	[illegible]
8	4.10	.....	3.50	4.00	24	4.10	3.60	3.60	[illegible]
9	4.10	.....	3.60	4.00	25	4.00	3.60	3.65	[illegible]
10	4.10	.....	3.65	4.00	26	4.10	3.50	3.25	[illegible]
11	4.00	.....	3.65	4.20	27	4.00	3.50	3.35	[illegible]
12	4.00	3.85	3.70	5.20	28	4.00	3.50	3.00	[illegible]
13	4.00	3.90	3.65	5.00	29	4.10	3.50	3.20	[illegible]
14	4.00	4.00	3.65	5.20	30	4.00	3.45	3.60	[illegible]
15	3.11	3.95	3.60	5.20	31	.....	3.45	.....	.....
16	4.10	3.95	3.60	5.20					

ST. MARY RIVER AT MAIN, MONT.

This station was established by C. C. Babb, July 14, 1901, and is located at the highway bridge at Main, about 1 mile below the mouth of Swiftcurrent Creek. During 1900 a number of measurements were made at this point, and a temporary bench mark was established, consisting of a notch in the timber on the downstream side of the right abutment. When the station was established the height of this notch on the gage was found to be 1.60 feet. The rod is vertical and is spiked to the timbers on the lower end of the left abutment. Bench mark No. 1 is a nail in the blaze of a cottonwood tree 13 feet northwest of the rod, and is at an elevation of 4,418.49 feet. Bench mark No. 2 is a temporary bench mark of the topographic division, consisting of a stone in the road 400 feet northwest of the bridge, at an elevation of 4,419 feet. The elevation of the zero of the rod is 4,411.72. The channel above and below the station is straight, and the velocity of the water is swift. The right bank is high, and the left bank is low and liable to overflow. A short distance west of the bridge is a slough which carries some water during flood stages, and, therefore, has to be gaged on such occasions. The bed of the stream consists of gravel and bowlders. The station was discontinued November 1, 1902. Stations at Dam Site and at Henkel's ranch give the discharge at Main.

Discharge measurements of St. Mary River at Main, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 9	J. S. Baker	0.10	168
August 22	W. B. Freeman	1.50	944
September 2	do	1.11	661
September 22	C. T. Prall	.61	420
September 30	W. B. Freeman	.61	407
October 8	C. T. Prall	.57	402
October 17	do	.55	402
October 23	do	.35	311
October 30	do	.25	281

Daily gage height, in feet, of St. Mary River at Main, Mont.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1902.										
1	0.05	0.25	0.05	−0.05	0.70	4.40	3.40	2.25	1.25	0.30
2	.00	.25	.05	− .05	.75	4.20	3.70	2.15	1.15	.40
3	.00	.25	.05	− .05	.75	4.00	6.25	2.05	1.05	.40
4	.00	.25	.05	.00	.80	3.70	6.50	1.95	1.00	.40
5	.00	.25	.00	.00	.90	3.60	5.80	1.90	1.00	.30
6	− .10	.20	.00	.05	.95	3.40	5.00	1.90	1.00	.30
7	− .10	.20	.00	.05	1.00	3.30	4.80	1.90	1.00	.30
8	− .10	.20	.00	.10	1.10	3.30	4.00	1.90	1.00	.25
9	− .10	.20	.05	.10	1.30	3.40	3.60	1.95	.90	.25
10	− .15	.20	.05	.10	1.60	3.50	3.40	1.95	.90	.25
11	− .15	.15	.05	.15	1.80	3.50	3.20	1.95	.90	.20
12	− .15	.15	.10	.15	2.00	3.40	.....	1.90	.85	.20
13	− .10	.15	.10	.20	2.30	3.40	2.90	1.85	.85	.20
14	+ .10	.15	.10	.20	2.80	3.30	2.80	1.80	.80	.25
15	.10	.10	.10	.20	3.10	3.40	2.70	1.75	.75	.20
16	.15	.10	.10	.30	3.40	3.30	2.60	1.70	.80	.20
17	.15	.10	.10	.40	3.80	3.20	2.60	1.70	.80	.20
18	.20	.10	.10	.40	3.90	3.10	2.50	1.70	.75	.25
19	.20	.10	.05	.50	3.60	3.00	2.40	1.65	.75	.....
20	.20	.10	.05	.50	4.20	2.90	2.30	1.60	.70	.....
21	.20	.05	.05	.50	5.00	2.80	2.40	1.65	.60	.....
22	.15	.05	.05	.55	4.50	3.10	2.40	1.60	.50	.....
23	.15	.05	.00	.55	4.40	3.10	2.50	1.50	.40	.....
24	.15	.05	.00	.60	4.50	3.10	2.50	1.50	.35	.....
25	.15	.05	.00	.60	4.40	3.10	2.60	1.50	.35	.....
26	.15	.05	.00	.65	4.30	3.30	2.60	1.50	.35	.....
27	.15	.05	− .05	.65	4.25	3.30	2.60	1.45	.30	.....
28	.15	.05	− .05	.65	4.35	3.30	2.60	1.45	.30	.....
29	.20	.....	− .05	.70	4.60	3.30	2.50	1.40	.30	.....
30	.20	.....	− .05	.70	4.80	3.40	2.45	1.35	.30	.....
31	.20	.....	− .05	.....	4.50	.....	2.35	1.30	.....	.....

Rating table for St. Mary River at Main, Mont.

FROM JANUARY 1 TO JUNE 30, 1902.

Gage height.	Discharge.	Gage height.	Discharge	Gage height.	Discharge.	Gage height.	Discharge
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
−1.4	41	0.8	415	3.0	2,422	5.2	5,106
−1.2	48	1.0	501	3.2	2,666	5.4	5,350
−1.0	57	1.2	587	3.4	2,910	5.6	5,594
−.8	70	1.4	673	3.6	3,154	5.8	5,838
−.6	87	1.6	790	3.8	3,398	6.0	6,082
−.4	108	1.8	960	4.0	3,642	6.2	6,326
−.2	137	2.0	1,202	4.2	3,886	6.4	6,570
.0	175	2.2	1,446	4.4	4,130	6.6	6,814
.2	220	2.4	1,690	4.6	4,374	6.8	7,058
.4	273	2.6	1,934	4.8	4,618		
.6	338	2.8	2,178	5.0	4,862		

FROM JUNE 30 TO DECEMBER 31, 1902.

−1.0	57	0.0	190	1.0	612	2.0	1,290
−.8	70	.2	257	1.2	720	[a] 2.2	1,446
−.6	87	.4	330	1.4	842		
−.4	108	.6	424	1.6	986		
−.2	143	.8	518	1.8	1,138		

[a] From this height the tables are the same.

Estimated monthly discharge of St. Mary River at Main, Mont.

[Drainage area, 298 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
January	220	146	193	11,867	0.65	0.75
February	232	185	205	11,385	.69	.72
March	195	165	181	11,129	.61	.70
April	373	165	257	15,292	.86	.96
May	4,862	373	2,490	153,104	8.36	9.67
June	4,130	2,178	2,873	170,955	9.64	10.76
July	6,692	1,568	2,737	168,292	9.18	10.58
August	1,507	780	1,090	67,010	3.66	4.22
September	750	293	488	29,038	1.64	1.83
October 1 to 18			282	10,074	.95	.64

SWIFTCURRENT CREEK AT HENKEL'S RANCH, NEAR ST. MARY, MONT.

This station was originally established April 8, 1902, by J. S. Baker, and was located one-half mile northwest of Henkel's ranch and 36 miles northwest of Browning, Mont. The nearest post-office is Wetzel. Henkel's ranch is reached by regular stage from Wetzel, Mont. The gage is of the usual wire type, with the gage rod graduated to feet and tenths. It is firmly nailed to a horizontal support, and is read daily by Henry Henkel. The initial point for sounding is on the left bank, and measurements are made from a cable and car. The channel is straight for 500 feet above and 200 feet below the station. The right bank is low and liable to overflow; the left bank is high and rocky. The bed of the stream is rocky. The station as originally established by J. S. Baker was washed away by the high water in June, 1902, and was reestablished July 30, 1902, by W. W. Schlecht. The original gage was placed on the right bank of the stream. The new gage is located 1,800 feet above the first gage and on the same bank of the stream. The gage was again moved on September 27, 1902, by C. T. Prall, as the second location was directly above a dam. The present gage is located about 900 feet above the former station. The length from the pointer to the bottom of the weight is 14.60 feet. The distance from the zero of the rod to the outside of the pulley is 2.15 feet. Bench mark No. 1 is a point chipped on a large bowlder 32.4 feet south of the gage. Its elevation is 12.52 feet above the zero of the gage. Bench mark No. 2 is the head of a 20-penny wire nail driven in a cottonwood tree 64.4 feet east of the gage. Its elevation is 12.86 feet above the zero of the gage.

Discharge measurements of Swiftcurrent Creek at Henkel's ranch, near St. Mary, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 9	J. S. Baker	1.50	67
Do	do	1.50	68
August 11	W. B. Freeman	2.40	338
August 22	do	2.22	254
September 2	do	1.94	170
October 8	do	2.00	156
October 17	C. T. Prall	1.92	139
October 23	do	1.70	101
October 30	do	1.68	98
July 30	W. B. Freeman	2.50	418
September 22	C. T. Prall	1.85	113
September 29	do	2.05	163

Daily gage height, in feet, of Swiftcurrent Creek at Henkel's ranch near St. Mary, Mont.

Day.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1	.....	2.00	5.00	3.20	2.50	2.00	1.90	1.60	1.4
2	.....	2.20	4.60	3.50	2.40	2.10	1.90	1.60	1.4
3	.....	2.40	4.00	5.00	2.40	2.10	1.90	1.50	1.4
4	.....	2.20	3.50	7.00	2.40	2.00	1.90	1.50	1.4
5	.....	2.20	3.30	6.30	2.30	2.10	1.80	1.50	1.4
6	.....	2.00	2.90	5.40	2.30	2.50	1.90	1.50	1.4
7	.....	2.00	3.10	5.00	2.20	2.40	1.90	1.50	[illegible]
8	1.50	2.00	3.10	4.70	2.10	2.10	1.90	1.50	[illegible]
9	1.50	2.60	3.50	3.80	2.10	2.10	1.90	1.50	[illegible]
10	1.50	2.80	3.80	3.20	2.40	2.10	1.90	1.50	[illegible]
11	1.50	2.90	4.00	3.00	2.30	2.00	1.90	1.50	[illegible]
12	1.50	2.90	4.00	3.00	2.30	2.00	1.90	1.50	[illegible]
13	1.40	3.10	4.10	2.80	2.30	2.00	1.80	1.50	[illegible]
14	1.40	3.10	3.50	2.80	2.30	1.90	1.80	1.50	[illegible]
15	1.50	4.00	3.30	2.70	2.20	1.90	1.80	1.50	[illegible]
16	1.60	4.10	3.20	2.70	2.20	2.00	1.80	1.50	[illegible]
17	1.60	4.40	3.20	2.60	2.20	2.00	1.80	1.50	[illegible]
18	1.60	4.40	3.10	2.60	2.20	1.90	1.70	1.50	[illegible]
19	1.60	4.00	3.00	2.50	2.30	1.90	1.70	1.50	[illegible]
20	1.80	4.40	3.00	2.40	2.30	1.90	1.70	1.50	[illegible]
21	2.00	5.70	2.70	2.40	2.30	1.90	1.70	1.50	[illegible]
22	2.10	4.90	2.60	2.30	2.20	1.90	1.70	1.50	[illegible]
23	2.30	4.70	2.40	2.30	2.20	1.90	1.70	1.50	[illegible]
24	2.30	4.30	2.20	2.40	2.20	1.90	1.70	1.50	[illegible]
25	2.00	4.10	2.20	2.30	2.20	1.80	1.70	1.40	[illegible]
26	2.00	3.90	3.50	2.50	2.20	2.00	1.60	1.40	[illegible]
27	2.00	3.70	3.50	2.40	2.20	2.00	1.60	1.40	[illegible]
28	2.00	3.80	3.40	2.70	2.20	2.00	1.60	1.40	[illegible]
29	2.00	4.50	3.40	2.70	2.20	2.00	1.60	1.40	[illegible]
30	2.00	5.00	3.20	2.50	2.20	2.00	1.70	1.40	[illegible]
31	.....	5.30	.....	2.50	2.10	.....	1.60	.....	[illegible]

a River frozen.

Rating table for Swiftcurrent Creek near St. Mary, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	36	2.8	578	4.6	1,577	6.4	2,576
1.2	45	3.0	689	4.8	1,688	6.6	2,687
1.4	58	3.2	800	5.0	1,799	6.8	2,798
1.6	78	3.4	911	5.2	1,910	7.0	2,909
1.8	108	3.6	1,022	5.4	2,021	7.2	3,020
2.0	156	3.8	1,133	5.6	2,132	7.4	3,131
2.2	245	4.0	1,244	5.8	2,243	7.6	3,242
2.4	356	4.2	1,355	6.0	2,354	7.8	3,353
2.6	467	4.4	1,466	6.2	2,465		

Estimated monthly discharge of Swiftcurrent Creek at Henkel's ranch near St. Mary, Mont.

[Drainage area, 101 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April *a*			109	6,485	1.08	1.20
May	1,966	156	989	60,811	9.79	11.30
June	1,799	245	880	52,360	8.71	9.71
July	2,909	301	836	51,404	8.28	9.55
August	412	190	276	16,971	2.73	3.15
September	412	108	168	9,996	1.66	1.85
October	128	78	106	6,517	1.05	1.21
November	78	58	66	3,927	.65	.73

a Discharges from 1st to 7th estimated.

ST. MARY RIVER AT DAM SITE NEAR ST. MARY, MONT.

This station was established April 9, 1902, by J. S. Baker. It is located on Henry Henkel's ranch, about 1 mile east of his house, and is 35 miles northwest of Browning, Mont. It is also about 4,500 feet below Lower St. Mary Lake. The gage, which is located about 1,000 feet above the cable from which the measurements are made, is of the usual wire type. It is supported upon a horizontal arm which extends over the river and is fastened to a cottonwood stump. The scale board is graduated to feet and tenths. The length of the wire from the bottom of the weight to the marker is 11.40 feet. The observer is Henry Henkel, who lives about 1 mile west of the gage. The channel is straight both above and below the station and the banks are high. The stream has a moderate velocity and the banks have gentle slopes. The bed of the stream is composed of gravel and bowlders. The initial point for soundings is on the left bank at the middle of the cottonwood tree to which the cable is fastened. Bench mark No. 1 is a spike in the foot of a cottonwood tree 30 feet north of the gage. It is marked B. M. 9.24. Its elevation above the zero of the gage is 9.24 feet. Bench mark No. 2 is a wire spike in the rear post of the gage. It is marked B. M. 6.97 feet. Its elevation above the zero of the gage is 6.97 feet.

Discharge measurements of St. Mary River at dam site near St. Mary, Mont.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
April 9	J. S. Baker	1.50	94
April 9	do	1.50	97
July 31	W. W. Schlecht	3.55	1,179
August 5	W. B. Freeman	3.20	992
August 12	do	3.05	897
August 23	do	2.73	626
September 2	do	2.47	487
September 22	C. T. Prall	2.00	355
September 29	W. B. Freeman	1.92	267
October 8	do	1.85	232
October 24	A. M. Gilbert	1.73	205
October 30	C. T. Prall	1.65	182

Daily gage height, in feet, of St. Mary River at dam site near St. Mary, Mont.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.									
1	.....	1.70	6.10	4.20	3.50	2.50	1.90	1.70	1.50
2	.....	1.80	6.00	4.40	3.40	2.40	1.90	1.70	1.50
3	.....	2.00	6.00	4.90	3.30	2.40	1.90	1.70	1.50
4	.....	2.00	5.30	6.50	3.30	2.40	1.90	1.70	1.50
5	.....	2.00	5.00	6.60	3.20	2.30	1.80	1.60	1.50
6	.....	2.00	4.60	6.40	3.20	2.30	1.80	1.60	1.50
7	.....	2.00	4.10	6.00	3.10	2.30	1.80	1.60	(a)
8	.....	2.00	4.10	5.80	3.10	2.30	1.80	1.60	.....
9	1.50	2.20	4.30	5.50	3.10	2.20	1.80	1.60	.....
10	1.50	2.20	4.30	5.20	3.10	2.20	1.80	1.60	.....
11	1.50	2.20	4.40	5.00	2.90	2.10	1.80	1.60	.....
12	1.50	2.20	4.30	5.00	3.00	2.10	1.80	1.60	.....
13	1.50	2.20	4.30	4.60	3.00	2.10	1.80	1.60	.....
14	1.50	2.30	4.10	4.60	3.00	2.10	1.80	1.60	.....
15	1.60	3.00	4.40	4.20	3.00	2.00	1.80	1.60	.....
16	1.60	3.20	4.30	4.20	3.00	2.10	1.80	1.60	.....
17	1.60	4.30	4.20	4.20	2.90	2.10	1.80	1.60	.....
18	1.60	4.30	4.00	4.10	2.90	2.00	1.80	1.60	.....
19	1.60	4.70	4.00	4.10	2.90	2.00	1.80	1.60	.....
20	1.50	5.60	4.00	4.00	2.90	2.00	1.80	1.60	.....
21	1.50	6.00	3.80	4.00	2.90	2.00	1.80	1.60	.....
22	1.60	6.00	3.60	4.00	2.80	2.00	1.80	1.60	.....
23	1.70	6.00	3.50	3.90	2.80	2.00	1.80	1.60	.....
24	1.80	6.30	3.20	4.00	2.70	2.00	1.80	1.60	.....
25	1.80	6.10	3.20	4.00	2.70	1.90	1.80	1.50	.....
26	1.60	6.00	3.80	4.10	2.70	1.90	1.70	1.50	1.50
27	1.60	6.00	3.70	3.90	2.70	1.90	1.70	1.50	1.50
28	1.60	5.00	4.00	3.90	2.70	1.90	1.70	1.50	1.50
29	1.60	5.10	4.00	3.80	2.60	1.90	1.70	1.50	1.50
30	1.70	6.00	3.80	3.60	2.60	1.90	1.70	1.50	1.60
31	.....	6.00	.....	3.50	2.60	.....	1.70	.....	1.60

a River frozen.

Rating table for St. Mary River at dam site near St. Mary, Mont., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	27	2.6	600	4.2	1,560	5.8	2,520
1.2	37	2.8	720	4.4	1,680	6.0	2,640
1.4	67	3.0	840	4.6	1,800	6.2	2,760
1.6	140	3.2	960	4.8	1,920	6.4	2,880
1.8	225	3.4	1,080	5.0	2,040	6.6	3,000
2.0	310	3.6	1,200	5.2	2,160	6.8	3,120
2.2	395	3.8	1,320	5.4	2,280		
2.4	480	4.0	1,440	5.6	2,400		

Estimated monthly discharge of St. Mary River at dam site near St. Mary, Mont.

[Drainage area, 177 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1902.						
April 9–30			136	5,931	0.77	0.63
May	2,820	310	1,359	83,561	7.68	8.85
June	2,700	960	1,608	95,682	9.09	10.14
July	3,000	1,140	1,792	110,186	10.12	11.67
August	1,140	600	813	49,989	4.59	5.29
September	540	267	357	21,243	2.02	2.25
October	267	182	222	13,656	1.25	1.44
November	182	97	137	8,152	.77	.86
December 1–6 and 26–31			136	3,237	.77	.38

RED RIVER AT EMERSON, MANITOBA.

This station was established by C. M. Hall, July 26, 1900, and is located at the Emerson railway and traffic bridge one-half mile north of the international boundary line at Emerson, Manitoba. It consists of a board 1 by 6 inches, painted white, grooved, graduated to feet and tenths, and attached to the east side of the breakwater for the center stone pier of the bridge. The zero of the gage is 46.5 feet below a steel beam of the bridge directly over the gage, and its elevation is 747.915 feet above sea level. The bed and the banks of the stream consist of clay. Measurements are usually made from a row-boat. The observer for 1902 is Robert Rossall, Emerson.

This station now replaces the station at Pembina, N. Dak. The readings here were not kept up in 1901 while the gage was maintained at Pembina station, but were resumed when the ice broke up in 1902, the Pembina station having been discontinued.

The following measurement was made by C. M. Hall in 1902:

April 26: Gage height, 12.70 feet; discharge, 7,646 second-feet.

Daily gage height, in feet, of Red River at Emerson, Manitoba.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1		30.45	14.20	15.35	9.65	5.70	4.40	3.70	[illegible]
2		31.35	15.90	14.75	9.30	5.55	4.40	3.70	[illegible]
3		31.90	18.15	14.20	8.95	5.45	4.35	3.75	[illegible]
4		32.10	20.15	13.60	8.70	5.30	4.30	3.80	[illegible]
5		31.85	21.50	13.20	8.50	5.20	4.30	3.80	[illegible]
6		30.95	22.50	12.95	8.40	5.20	4.40	3.80	[illegible]
7		30.10	23.10	12.80	8.35	5.10	4.40	3.80	[illegible]
8		28.90	23.10	12.80	8.25	5.10	4.40	3.80	[illegible]
9		27.15	23.05	13.05	8.20	5.05	4.30	3.80	[illegible]
10		25.40	22.65	13.55	8.20	5.00	4.30	3.70	[illegible]
11		23.65	21.80	14.05	8.35	5.00	4.30	3.70	[illegible]
12		22.15	21.00	14.50	8.55	4.95	4.35	3.70	[illegible]
13		20.45	20.20	14.65	8.70	4.80	4.40	3.70	[illegible]
14		19.15	19.45	14.75	8.50	4.65	4.30	3.65	[illegible]
15		17.95	18.65	14.70	8.25	4.55	4.25	3.60	[illegible]
16		17.05	17.90	14.60	8.15	4.45	4.15	3.60	[illegible]
17		16.40	17.30	14.40	7.90	4.40	4.10	3.60	[illegible]
18		15.95	16.75	14.15	7.55	4.30	4.10	3.55	[illegible]
19		15.65	16.20	13.90	7.35	4.30	4.00	3.50	[illegible]
20		15.20	15.90	13.65	7.25	4.30	3.90	3.50	[illegible]
21		14.85	15.90	13.45	6.95	4.45	3.80	3.50	[illegible]
22		14.45	16.05	13.05	6.65	4.70	3.75	3.50	[illegible]
23		14.05	16.35	12.80	6.50	4.90	3.70	3.50	[illegible]
24		13.45	16.95	12.55	6.45	4.90	3.70	3.50	[illegible]
25		13.10	17.35	12.10	6.25	4.85	3.70	3.55	[illegible]
26		12.70	17.55	11.75	6.05	4.65	3.60	3.60	[illegible]
27	18.20	12.30	17.60	11.30	5.85	4.45	3.60	3.65	.....
28	21.90	12.00	17.35	10.90	5.70	4.40	3.60	3.75	.....
29	25.10	12.30	17.00	10.45	6.00	4.40	3.60	3.90	.....
30	27.50	13.25	16.40	10.00	5.95	4.40	3.60	4.05	.....
31	29.35	.....	15.95	.....	5.75	4.40	.....	4.55	.....

RED LAKE RIVER AT CROOKSTON, MINN.

This station was established by C. M. Hall, May 19, 1901. It is located at the bridge connecting Robert street and St. Paul street, which is known as the Sampson addition bridge. The gage consists of a weight attached to a woven steel-wire rope which plays over a pulley attached to the center of the single-span bridge. Readings are made on a board 1 by 6 inches, painted white, graduated to feet and tenths, and attached to the east railing of the bridge. A similar gage board nailed to one of the south piers of the bridge is used for reading high-

water stages. The zero of the gage is 820.07 feet above sea level and 9.8 feet below the bench mark, which is marked by one 20-penny and three 8-penny nails driven into the east end of the breakwater under the north end of the bridge:

During 1902 the following discharge measurements were made by C. M. Hall:

May 3: Gage height, 9.95 feet; discharge 5.009 second-feet.
May 30: Gage height, 7.85 feet; discharge, 3,154 second-feet.
July 31: Gage height, 5.35 feet; discharge, 1,472 second-feet.

Daily gage height, in feet, of Red Lake River at Crookston, Minn.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	.....	8.05	8.15	8.10	6.60	4.75	5.10	5.10	5.18
2	.....	7.75	8.75	7.90	6.70	5.30	5.05	5.25	5.15
3	.....	7.15	9.95	8.30	6.75	5.30	4.95	5.20	5.20
4	.....	7.05	9.65	9.10	6.85	5.40	4.95	5.40	5.18
5	.....	7.35	9.55	9.16	6.93	5.45	4.98	5.07	5.22
6	.....	7.25	9.05	9.10	7.00	5.70	5.00	5.00	5.40
7	.....	6.75	8.90	9.20	6.95	5.60	5.00	4.90	5.45
8	.....	7.25	8.60	9.60	6.93	5.00	4.90	4.95	5.30
9	.....	6.70	8.40	9.80	.....	4.30	4.85	5.01	5.35
10	.....	6.55	8.50	9.70	.....	5.30	4.88	5.04	5.40
11	.....	6.05	8.60	9.60	.....	4.90	4.90	5.02	5.45
12	.....	6.15	8.70	9.60	6.60	5.00	4.95	5.00	5.50
13	[a] 7.40	5.85	8.70	9.50	6.50	4.70	4.93	4.98	5.53
14	7.38	5.80	8.80	9.70	6.60	4.50	4.85	4.95	5.50
15	7.42	6.55	8.60	9.30	6.55	4.80	4.83	4.97	5.45
16	.....	6.25	8.50	9.10	6.40	5.30	4.70	4.99	5.50
17	7.63	6.05	8.60	9.00	6.35	4.50	4.70	5.01	5.51
18	7.68	6.25	8.80	9.00	6.30	5.00	4.64	5.04	5.58
19	7.70	5.60	9.10	9.00	6.30	5.60	4.64	5.05	5.60
20	7.85	6.15	9.60	9.00	6.28	5.40	4.65	5.03	5.57
21	7.65	5.15	10.00	8.60	6.25	5.20	4.70	5.03	5.55
22	7.60	5.85	9.80	8.50	6.23	5.10	4.75	5.00	5.53
23	7.95	5.85	9.75	8.50	6.20	4.90	4.74	5.05	5.50
24	8.10	5.85	9.00	8.30	5.95	4.95	4.80	5.10	4.98
25	8.55	5.15	8.98	8.00	5.84	5.00	4.83	5.20	4.96
26	8.81	5.95	8.75	7.40	5.20	5.05	4.86	5.40	4.99
27	9.25	7.75	8.60	7.05	5.15	5.10	4.85	5.34	5.52
28	9.85	7.65	8.60	7.00	4.85	5.10	4.87	5.40	5.54
29	9.60	7.95	8.52	6.90	4.60	5.15	4.90	5.37	5.56
30	9.55	8.00	8.40	6.70	4.92	5.20	4.96	5.35	.....
31	9.00	.....	8.40	.....	4.90	5.10	.....	5.30	.....

[a] Frozen during the winter. Elevation of surface of the ice 7.25 to 7.40 feet on gage. Ice 18 inches thick.

RED RIVER AT GRAND FORKS, N. DAK.

This station was established by C. M. Hall May 26, 1901, and is located at the Northern Pacific Railway bridge crossing the river at Grand Forks, N. Dak. The gage consists of a 1 by 8 inch board, painted white, graduated to feet and tenths in black, and attached to the north end of the breakwater for the center pier of the bridge.

The zero of the gage was placed 5 feet below the zero of the United States engineers' gage attached to the same breakwater, and is 779 feet above sea level according to leveling done by the Corps of Engineers, United States Army. The danger line is at 40 feet. The channel is straight above the station. The bed of the river is composed of mud and fine sand and is changeable; the water is usually heavily laden with sediment from Red Lake River, which enters one-half of a mile above the station. Measurements are made from a rowboat about 150 yards below the gage. The observer is John F. Hayes.

During 1902 the following discharge measurements were made by C. M. Hall:

May 17: Gage height, 15.10 feet; discharge, 6,613 second-feet.[a]
May 30: Gage height, 15.70 feet; discharge, 7,136 second-feet.[a]

Daily gage height, in feet, of Red River at Grand Forks, N. Dak.[b]

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.					1902.				
1	2.30	1.18	3.65	.....	12	1.95	1.35	1.35	.....	23	1.55	1.15	3.80	.....
2	1.95	1.38	3.85	.....	13	1.75	1.22	1.70	.....	24	1.30	1.28	3.50	.....
3	2.25	1.62	3.70	.....	14	1.65	1.15	2.70	.....	25	1.28	1.48	3.45	.....
4	2.30	1.58	3.58	.....	15	1.80	1.08	3.30	.....	26	1.50	1.70	3.20	.....
5	1.95	1.58	3.45	.....	16	1.50	1.62	3.00	.....	27	1.62	1.70	3.50	.....
6	2.15	1.52	3.30	.....	17	1.45	1.50	3.75	.....	28	1.60	2.55	3.20	.....
7	2.05	1.35	3.10	.....	18	1.52	1.38	4.00	.....	29	1.60	2.92	3.00	.....
8	2.25	1.52	3.20	.....	19	1.30	1.30	4.10	.....	30	1.68	3.52	.....	.....
9	2.10	1.53	3.18	.....	20	1.35	1.35	4.20	.....	31	.....	3.50	.....	.....
10	2.05	1.35	2.60	.....	21	1.50	1.22	4.22	.....					
11	2.05	1.55	2.05	.....	22	1.30	1.00	3.85	.....					

SHEYENNE RIVER AT HAGGART, N. DAK.

This station was established March 22, 1902, by Charles M. Hall. It is located near the way station of Haggart, on the Northern Pacific Railroad, 5 miles west of Fargo, N. Dak. The gage is a plain staff graduated to feet and tenths attached to the bridge. It is read daily by James Haggart, jr., who lives about half a mile from the bridge. The channel is straight both above and below the river. The bed of the stream is of clay and slightly shifting.

During 1902 the following discharge measurements were made by C. M. Hall:

April 30: Gage height, 7.90 feet; discharge, 643 second-feet.
May 31: Gage height, 5.50 feet; discharge, 346 second-feet.
September 30: Gage height, 3.70 feet; discharge, 49 second-feet.

[a] Gage height read on Geological Survey gage.
[b] Daily gage heights read on engineers' gage: add 5.00 feet to reduce to U. S. Geol. Survey gage datum.

Daily gage height, in feet, of Sheyenne River at Haggart, N. Dak.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.									
1	.....	13.00	8.00	5.50	4.10	3.80	3.80	3.70	3.90
2	.....	14.80	8.10	5.60	4.20	3.80	3.80	3.90	3.90
3	.....	15.90	8.10	5.70	4.50	4.00	3.80	3.90	3.90
4	.....	16.20	8.00	5.50	4.40	4.10	3.80	4.00	3.90
5	.....	16.50	8.10	5.50	4.30	4.00	3.80	3.90	3.90
6	.....	17.00	8.00	5.40	4.20	3.90	3.80	3.80	4.00
7	.....	17.20	7.90	5.40	4.20	3.70	3.80	3.70	4.00
8	.....	17.40	7.80	5.40	4.10	3.80	3.80	4.00	4.00
9	.....	18.00	7.60	5.70	4.00	3.80	3.80	4.00	.....
10	.....	18.00	7.60	6.10	4.30	3.70	3.80	4.10	.....
11	.....	18.00	7.50	6.50	4.20	3.70	3.80	3.90	.....
12	.....	17.00	7.50	6.70	4.20	3.60	3.70	3.70	.....
13	.....	16.40	7.60	6.60	4.00	3.60	3.70	3.70	.....
14	.....	16.00	7.40	6.20	3.80	3.80	3.70	3.70	.....
15	.....	15.80	7.20	5.70	3.80	3.80	3.70	3.60	.....
16	.....	15.50	7.00	5.30	3.70	3.60	3.60	3.60	.....
17	.....	15.20	7.20	5.20	3.90	3.50	3.60	3.70	.....
18	.....	15.00	7.00	5.10	4.00	3.40	3.80	3.80	.....
19	.....	14.80	7.10	5.00	4.00	3.40	3.90	3.90	.....
20	.....	14.80	7.20	5.00	3.80	3.60	3.80	4.00	.....
21	.....	14.20	7.20	4.90	3.70	3.70	3.90	3.90	.....
22	.....	12.30	7.30	4.80	3.80	3.60	3.80	3.80	.....
23	.....	11.60	7.30	4.70	3.80	3.80	3.70	3.40	.....
24	.....	10.40	7.40	4.80	3.90	3.80	3.60	3.70	.....
25	.....	10.20	7.30	4.80	4.00	4.00	3.80	4.20	.....
26	.....	9.80	7.20	4.60	3.80	4.10	4.00	4.40	.....
27	.....	9.20	6.90	4.40	4.00	4.00	4.10	4.20	.....
28	.....	8.60	6.60	4.50	4.50	4.00	4.00	4.00	.....
29	9.50	8.00	6.30	4.40	4.00	3.80	4.00	4.10	.....
30	10.20	7.90	6.00	4.20	3.60	3.70	3.80	4.00	.....
31	12.10	.....	5.60	.....	3.80	3.60	.....	4.00	.....

RED RIVER AT FARGO, N. DAK.

This station was established by C. M. Hall May 27, 1901, and is located at the bridge connecting Front street, Fargo, N. Dak., and Main street, Moorhead, Minn. The gage consists of a 1 by 8 inch board, painted white, graduated to feet and tenths in black, and attached to the east side of the breakwater for the center pier of the bridge. The zero of the gage is 44.45 feet below the top of the plank walk of the bridge over the gage and is 860.9 feet above sea level, the elevation having been determined by leveling from top of rail of Northern Pacific station, Moorhead, Minn. The danger line is at 26.5 feet. Above the station the river curves to the west. The west bank is high and steep; the east bank low and subject to overflow at times of high water. Measurements are made from the bridge. The river bed consists of soft mud. The observer is H. W. Grasse, United States Weather Bureau, Moorhead, Minn.

During 1902 the following discharge measurements were made by C. M. Hall:

May 2: Gage height, 8.15 feet; discharge, 555 second-feet.
May 20: Gage height, 9.87 feet; discharge, 1,240 second-feet.

Daily gage height, in feet, of Red River at Fargo, N. Dak.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.											
1		8.70	9.00	8.10	9.20	9.30	8.20	7.70	7.30	7.50	[illegible]
2		8.70	8.90	8.00	9.10	9.20	8.20	7.70	7.30	7.50	[illegible]
3		8.70	8.60	8.10	9.10	9.20	8.30	7.70	7.30	7.40	
4		8.70	8.30	8.10	9.20	9.30	8.40	7.70	7.30	7.40	
5		8.70	8.10	8.00	9.50	9.40	8.50	7.70	7.30	7.30	
6		8.70	8.00	8.10	9.60	9.40	8.50	7.70	7.30	7.30	
7		8.70	8.00	8.30	9.80	9.50	8.40	7.70	7.30	7.20	
8		8.70	8.00	8.50	9.90	9.50	8.30	7.60	7.30	7.20	
9		8.50	8.00	8.60	10.00	9.40	8.30	7.60	7.20	7.00	
10		8.30	8.30	8.80	10.10	9.30	8.20	7.60	7.20	6.90	
11		8.30	8.20	8.80	10.10	9.10	8.20	7.50	7.20	6.80	
12		8.40	8.30	8.80	10.10	9.10	8.20	7.50	7.20	6.80	
13		8.70	8.20	8.80	10.00	9.10	8.20	7.50	7.10	6.70	
14		8.80	8.20	8.80	10.00	9.10	8.20	7.50	7.10	6.70	
15		9.00	8.20	8.70	9.90	9.10	8.20	7.50	7.10	7.00	
16		9.80	8.20	8.20	9.80	9.10	8.20	7.50	7.00	7.30	
17		10.30	8.20	8.50	9.70	9.00	8.10	7.50	7.00	7.50	
18		10.30	8.10	9.00	9.70	8.90	8.00	7.40	7.00	7.80	
19		9.50	8.00	9.30	9.70	8.80	7.90	7.40	7.00	7.80	
20		9.10	7.90	9.80	9.70	8.70	8.00	7.40	7.00	7.80	
21		9.00	7.80	10.00	9.70	8.70	8.00	7.40	7.00	7.80	
22		9.10	7.80	10.40	9.70	8.60	7.90	7.40	6.90	7.80	
23		9.20	7.80	10.50	9.70	8.60	7.90	7.40	7.00	7.80	
24		9.30	7.80	10.30	9.70	8.50	7.90	7.40	7.10	7.80	
25	7.60	9.40	7.90	10.30	9.70	8.50	7.90	7.40	7.30	7.80	
26	8.20	9.50	7.90	10.40	9.70	8.40	7.80	7.40	7.50	7.70	
27	8.40	9.80	8.00	10.00	9.60	8.30	7.80	7.40	7.70	7.60	
28	8.70	9.80	8.00	9.60	9.50	8.20	7.80	7.40	7.80	7.40	
29		10.00	7.90	9.60	9.50	8.10	7.90	7.40	7.80	7.10	
30		9.50	7.90	9.40	9.40	8.20	7.80	7.30	7.70	6.80	
31		9.10		9.20		8.20	7.70		7.50		

DEVILS LAKE AT DEVILS LAKE, N. DAK.

This station was established by C. M. Hall, June 8, 1901, and is located at the boat landing at the Chautauqua grounds, 6 miles southwest of Devils Lake station, North Dakota. The object of maintaining a gage record on Devils Lake is to ascertain the fluctuations in its water level, which, during past years, has been steadily falling, the drop in the last nineteen years amounting to as much as 10 or 12 feet. The lake has no regular outlets and its waters are salt. It is hoped that a study of such records will lead to important conclusions relating to evaporation from the lake surface. The gage consists of a 2 by 8 inch plank, painted white, grooved, and graduated to feet and tenths, and

ttached to the middle of the north row of piles of the Chautauqua oat landing.

A United States Geological Survey bench mark is placed on the shore f the lake 3 rods west of the Chautauqua gate, which opens to the oat landing. It corresponds to the height of the lake in June, 1879, hich was preserved by a hard-wood post driven level with the water y Capt. E. E. Heerman. The bench mark is 1,439.08 feet above sea vel. The zero of the gage is 22.90 feet below the bench mark. The bserver is Capt. E. E. Heerman.

The following gage readings were taken during 1902:

Gage heights of Devils Lake in 1902.

April 23	Lake opened	June 23	13.97
April 25	13.55	June 27	13.95
April 29	13.60	July 15	13.70
April 30	13.60	August 7	13.50
May 5	13.80	August 23	13.70
May 7	13.85	September 13	13.20
May 24	13.95	September 28	13.20
June 5	14.00	October 12	13.10
June 10	13.95	October 22	13.05
June 13	14.10	November 15	13.00
June 22	14.00	November 15	Lake closed

The following table, furnished by E. E. Heerman of Devils Lake, N. Dak., gives the dates for the past twenty years of the opening and closing of Devils Lake, between Devils Lake and Fort Totten, N. Dak. This part of the lake is larger and deeper; consequently freezes over later than other parts of the lake, and opens later on account of the greater body of ice. It has been known to freeze 44 inches thick at this point.

Date of opening and closing of Devils Lake, N. Dak.

Year.	Opened.	Closed.	Year.	Opened.	Closed.
1882		November 19 or 20.	1893	May 14	November 11.
1883	May 2	November 18.	1894	May 3	November 15.
1884	May 11	November 16.	1895	April 17	November 7.
1885	May 12	November 14.	1896	May 3	Do.
1886	April 26	November 11.	1897	do	Do.
1887	May 7	November 19.	1898	April 28	November 13.
1888	April 25	November 15.	1899	May 10	December 2.
1889	April 16	November 14.	1900	April 23	November 12.
1890	April 30	November 30.	1901	April 24	November 14.
1891	April 28	Lost (late November).	1902	April 23	November 15.
1892	May 7	November 7.			

INDEX.

Page.

Abbotts Ferry, California, stream measurements at 159
Alvetriz ditch, California, seepage of 181
Amador ditch, California, measurements of 158
American River, California, measurements of 158
American Valley, California, stream measurements in 157
Animas River, Colorado, location of 16
measurements of 35-37
Angel's ditch, California, measurements below intake of 159
Antelope Valley, California, stream measurements at upper end of 108
Arroyo Seco, California, measurements of 163-165
Ash Canyon Creek, Nevada, measurements of 126
Ashley Creek, Utah, measurements of ... 71-73
Ashley River, Utah, location of 16
Auburn, Cal., stream measurements near. 158
Azusa, Cal., stream measurements at .. 167-171
Baby Ruth weir, California, stream measurements at 178
Baird, Cal., stream measurements at 156
Bakersfield, Cal., stream measurements near 154-155
Balls Ferry, Cal., stream measurements near 157
Balls Ferry Bridge, California, Sacramento River at, measurements of 156
Balls Ferry Flour Mills, California, stream measurements at 157
Banta ditch, California, measurements of. 177
Battle Creek, California, measurements in ditch of 157
Battle Creek Bridge, California, Sacramento River at, measurements of 157
Battlecreek, Idaho, stream measurements at 82-84
Bay Counties Power Company's dam, California, stream measurements below 157
Bay Counties Power Company's flume, California, stream measurements at 157
Beam ditch, California, natural flow in .. 180
Bear Creek, California, measurements of. 160
Bear River, measurements of, at Battlecreek, Idaho 82-84
measurements of, near Collinston, Utah 80-82
miscellaneous measurements of 158
Bennett & Kelley ditch, California, measurements of 162
Bidwell Bar, California, stream measurements at 157
Big Bend, California, stream measurements at 157
Big Bend Tunnel, California, stream measurements at 157
Big Blackfoot River, Idaho, measurements of 216
Big Canyon, California, measurements of. 158
Big Creek, California, measurements of. 160-161
Big Meadows, California, stream measurements at 157
Big Spring Branch of Feather River, California, measurements of 157
Big Trees Creek, California, measurements below mouth of 159
Bitterroot River, Montana, measurements of 201-203
Black Springs Creek, Idaho, measurements of 216
Blackfoot River, Idaho, mouth of, measments above 216
Blacksmith Fork, Utah, measurements of 84-86
Blue Canyon Creek, California, measurements of 160
Blue Creek, Little, Colorado, measurements of 77
Blue Lakes, Idaho, stream measurements at 216
Blue Lakes Creek, Idaho, measurements of 216
Blue Ravine mine, California, stream measurements at 158
Boca, Cal., stream measurements near .. 122
Boise, Idaho, regular gaging station at, stream measurements of 211
stream measurements near 207-210, 216
Boise River, Idaho, measurements of .. 207-211
seepage measurements made on, summary of 212
Boise Valley, Idaho, miscellaneous stream measurements in 211
seepage in 210

Page.
Boise Valley canal, Idaho, measurements of 211
Bonner, Idaho, stream measurements at . 216
Bonton Mills power house, California, measurements in flume at 160
Bowman's reservoir, California, discharge from 157
Bradley's home ranch, Nevada, stream measurements at 106
Bridal Veil Creek, California, measurements of 160
Bridgeport, Cal., stream measurements below 125
Bridgeport Bridge, California, Yuba River (South Fork) at, measurements of 157
Bruneau River, Idaho, measurements of 212-213
Brunnell Hotel, California, West Branch of Feather River at, measurements of 157
Bruns Creek, California, measurements of 126
Bubbs Creek, California, measurements of 161
Buckeye Creek, California, measurements of 125
Buckley, Wash., stream measurements at 217-218
Bulls Head, Arizona, stream measurements at 20-21
Burney, Cal., stream measurements at .. 156
Butt Valley Creek, California, measurements of 157
Cache Creek, California, measurements of 130-132, 157
source and course of 127
Cahoons place, California, Sequoia Natural Park line on, stream measurements at 161
Caldwell bridge, Idaho, Boise River at, measurements of 211
Caldwell Canyon, Idaho, stream measurements in 211
California, southern, stream measurements in drainage basin of .. 163-181
California-Nevada State line, stream measurements at 119-121
Camp Carlton, California, developed water at 180
Camp Seco River, California, measurements of 159
Carbon, Cal., stream measurements at .. 156
Cardston, Canada, stream measurements near 225-226
Carr's ranch, Colorado, stream measurements at 77
Carson River, miscellaneous measurements in basin of 125-126
Carson River (West Fork), California, measurements of 113-115
Carson River, Nevada, measurements of 109-111
Carson River (East Fork), Nevada, measurements of 111-113

Page
Castle Crags, Cal., stream measurements at ..... [illegible]
Cate ditch, California, measurements of. [illegible]
Catlin & Macey ditches, Idaho, measurements of ..... [illegible]
Cayote Creek, California, measurements of ..... [illegible]
Cebolla Creek, Colorado, measurements of ..... [illegible]
Cedar Lake, Washington, stream measurements at ..... [illegible]
Cedar River, measurements of, near Maple Valley, Washington .. [illegible]
measurements of, near Northbend, Wash ..... [illegible]
Cedars, Idaho, stream measurements between Shoshone Falls and ..... [illegible]
Cherry Creek, California, measurements of ..... [illegible]
Chillie Bar, California, stream measurements at ..... [illegible]
Chillie Bar Bridge, California, American River (South Fork) at, measurements of ..... [illegible]
Church canal, Calfornia, measurements of ..... [illegible]
Cimarron, Colo., stream measurements at [illegible]
Cimarron Creek, Little, Colorado, measurements of ..... [illegible]
Cimarron River, Colorado, measurements of ..... [illegible]
Cippoletti weir, California, headworks of, measurements at ..... [illegible]
City Creek, California, measurements of. [illegible]
Clarke's ranch, Colorado, stream measurements at ..... [illegible]
Clarks Fork, Stanislaus River, California, measurements at and near mouth of ..... [illegible]
Clear Creek, California, measurements of. [illegible]
Kern River below, measurements of. [illegible]
Clear Creek, Nevada, measurements of .. [illegible]
Clear Lake, California, evaporation of .... [illegible]
reservoir site at ..... [illegible]
Clements River, California, measurements of ..... [illegible]
Cliff camp, California, stream measurements near ..... [illegible]
Cohn and Harvey ditch, California, measurements at head of ..... [illegible]
Cohn's meadow, California, Petersons Creek above, measurements of ..... [illegible]
Coleville, Cal., stream measurements near ..... [illegible]
Colfax, Cal., stream measurments near. . [illegible]
Colliers, Cal., stream measurements below [illegible]
Collinston, Utah, stream measurements near ..... [illegible]
Colorado River, gaging stations in basin of ..... [illegible]
irrigation from ..... [illegible]
measurements of, at Bulls Head, Ariz [illegible]
at Yuma, Ariz ..... [illegible]
sediment carried by, amount of ..... [illegible]

Page.
Colorado River, source and course of 16
stream measurements in basin of 15-77
Colton, Cal., pumping plant at, developed water from 180
Colton Terrace Water Co.'s, California, developed water at 180
Columbia River, California, stream measurements in drainage basin of 181-216
Conway & Akin ditches, Idaho, measurements of 211
Copper City, Cal., Silverthorn Ferry at, measurements of 156
Squaw Creek near, measurements of. 156
Costin canal, Idaho, measurements of.... 211
Crafton canal, California, measurements of 180
Crafton weir, California, Mill Creek at, measurements of 180
Craig, Colo., stream measurements at ... 74-75
Crocker Hoffman canal, California, measurements of 160
Crockers, California, stream measurements between Hogranch and. 159
Crookston, Minn., stream measurements at 234-235
Crown Creek, California, measurements of 160
Cucamonga Creek, California, measurements of 179
Davis & Hart ditch, Idaho, measurements of 211
Davis canal, Idaho, measurements of 211
Davis ranch, California, Kaweah River, North Fork, at lower end of, measurements of 161
Deer Creek, California, measurements of. 160
Deeth, Nev., stream measurements near. 106
Delhi mine, California, stream measurements below 157
Democrat Springs, California, stream measurements at 162
Devils Lake, North Dakota, measurements of 238-239
stream measurements at 238-239
Diamond Valley, California, stream measurements at 125
Dinkey Creek, California, measurements of 160
Division weir, California, stream measurements at 178
Dixon, Colo., stream measurements near. 77
Dogtown Creek, California, measurements of 125
Dolores, Colo., stream measurements at.. 41-42
Dolores River, Colorado, measurements of 41-42
source and course of 16
Donner Creek, California, measurements of 123
Dotta or Lower Big Spring, California, measurements of 157
Doyle Power ditch, California, headworks of, stream measurements near. 161
Dressler Creek, Nevada, measurements of 126
Dry Creek canal, Idaho, measurements of. 211
Dubois, Colo., stream measurements between Spencer, Colo., and 77
Duchesne River, Utah, course of 16
measurements of 55-58
Durango, Colo., Animas River at, measments of 35-37
Florida River near, measurements of. 37-39
Eagle Island, Idaho, stream measurements at 211
East Branch (Feather River), California, measurements of 157
East Mount Moses, Cal., stream measurements at 161
Edison Electric Co., California, cable of, stream measurements at 162
Edwards Bridge, California, Yuba River (South Fork) at, measurements of 157
Eleanor Creek, California, measurements of 159
Electra, Cal., stream measurements at and near 158-159
Electric Light Works waste, Idaho, measurements of 211
Elk River, Colorado, measurements of.... 77
Elko, Nev., Humboldt River near, measurements of 103-105
Humboldt River (South Fork) near, measurements of 101-103
Ellis canal, Idaho, measurements of..... 211
Emerson, Canada, stream measurements at 233-234
Empire, Nev., stream measurements near 109-111
Enterprise, Cal., stream measurements at 157
Enterprise canal, California, measurements of 161
Eureka canal, Idaho, measurements of .. 211
Eureka Lake Co.'s ditch, California, measurements of 157
Evans ditch, California, seepage of 181
Evans Island ditch, California, seepage of 181
Excelsior Mining and Irrigation Co.'s canal, California, measurements of 157
Fairview Creek, Nevada, measurements of 126
Fall River, California, measurements of. 156
Fall River, Idaho, measurements of.... 215-216
Fall River Mills, Cal., stream measurements at 156
Falls Creek, California, measurements of 159
Fargo, N. Dak., stream measurements at 237-238
Farmer's Union canal, Idaho, measurements of 211
Faucherie Lake, California, discharge from 157
Feather River, California, measurements of 133-135, 157
source, drainage basin, and general features of 127-128
Florida River, Colorado, location of..... 16
measurements of 37-39
Folsom, Cal., stream measurements near. 158

Page.
Forbes, R. H., cited on sediment carried by Colorado River 15
Fort Crawford, Colo., stream measurements at 77
Fort Duchesne, Utah, stream measurements at 61-65
Fort Mountain, Cal., stream measurements near 158
Fountain of Life Spring weir, California, stream measurements at 178
Fowler Switch canal, California, measurements of 161
Freemans Bridge, California, Yuba River (Middle Fork), below, measurements of 157
French Lake, California, discharge from. 157
Fruto, Cal., stream measurements near.. 135-137
Gage canal, California, developed water in 180
Gardnerville, Nev., stream measurements near 111-113
Gate View, Colo., stream measurements at 77
Genoa Creek, Nevada, measurements of. 126
Gibbon, Oreg., stream measurements at 183-185
Gila River, Arizona, measurements of ... 32-35
miscellaneous measurements of 77
source and course of 16
Glenwood Springs, Colo., stream measurements at 48-50
Golconda, Nev., stream measurements near 98-100
Goldwin Mining Company, California, measurements in flume of 159
Goodwin Mill or Penault canal, Idaho, measurements of 211
Grand Forks, N. Dak., stream measurements at 235-236
Grand River, measurements of, at Glenwood Springs, Colo 48-50
measurements of, near Palisades, Colo 46-48
near Piney Creek, Colorado 77
source and course of 16
Grandview, Idaho, stream measurements at 212-213
Granite Creek, California, measurements of 160-161
Grantsdale, Mont., stream measurements near 201-203
Green Creek, California, measurements of 125
Green River, Wyoming, measurements of 75-77
source and course of 16
Greenhorn River, California, mouth of, flow at 158
Greenriver, Wyo., stream measurements at 75-77
Gunnison, Colo., stream measurements near 77
Gunnison, Utah, San Pitch River near, measurements of 94-96
Sevier River near, measurements of. 88-90
Gunnison River, measurements of, at Iola, Colo 44-46
Gunnison River, measurements of, at Whitewater, Colo ..... [illegible]
Hackett Meadow, California, lower end of, stream measurements at . [illegible]
Haggart, N. Dak., stream measurements at ..... [illegible]
Halleck, Nev., stream measurements near ..... [illegible]
Hamilton, Colo., stream measurements at [illegible]
Hamilton Bridge, California, East Branch of Feather River at, measurements of ..... [illegible]
Hat Creek, California, measurements of. [illegible]
Hawkins Creek, California, measurements of ..... [illegible]
Hayden, Colo., stream measurements at. [illegible]
Heitmans, Nev., spring near, discharge of [illegible]
Henkel's ranch, Montana, Swiftcurrent Creek at, measurements of.. [illegible]
Herndon, Cal., stream measurements at . [illegible] 156, [illegible]
Hetch Hetchy Valley, California, lower end of, stream measurements at ..... [illegible]
upper end of, stream measurements at [illegible]
Highlands canal, California, measurements of ..... [illegible]
Hirze Mountain, California, stream measurements at ..... [illegible]
Hog ranch, California, stream measurements between Crockers and. [illegible]
Hooper, Wash., stream measurements near ..... [illegible]
Hooper ditch, California, measurements of [illegible]
Horse Creek, California, measurements of ..... [illegible]
Horseshoe Bend, California, stream measurements at ..... [illegible]
Hot Springs, Cal., Thurston ditch on road to, measurements of..... [illegible]
Hoys Bridge, Nevada, stream measurements at ..... [illegible]
Hudson Bay, drainage basin of, stream measurements in ..... [illegible]
Huff Bar, California, stream measurements at ..... [illegible]
Humboldt River, measurements of, at Palisade, Nev ..... [illegible]
measurements of, below Pitt dam, Nevada ..... [illegible]
near Elko, Nev ..... [illegible]
near Golconda, Nev ..... [illegible]
near Oreana, Nev ..... [illegible]
miscellaneous measurements in basin of ..... [illegible]
Humboldt River (North Fork), Nevada, measurements of ..... [illegible]
Humboldt River (South Fork), Nevada, measurements of ..... [illegible]
Huntoon ranch, California, stream measurements below ..... [illegible]
Hydraulic Mining Company's canal, California, measurements of..... [illegible]
Hydrographers, resident, in various States and Territories 14-15
Hyrum, Utah, stream measurements at . [illegible]

Page.
Ianosa Water Company, California, head works of, stream measurements above 179
Ideal Valley, California, stream measurements at 160
Ignacio, Colo., stream measurements at.. 39-40
Illilouette Creek, California, measurements of 160
Imperial canal, Arizona, location and purpose of 15-16
measurements of 77
Independence Creek, California, measurements of 121-122
Independence Lake, California, measurements below 121-122
Index, Wash., stream measurements near 222-223
Indian Agency, California, Tule River below, measurements of 161
Indian Creek, California, measurements of 125
Indian Reservation, California, stream measurements between Nelson and 161
Indian Valley, California, stream measurements in 157
International boundary, stream measurements at 77
Interior, stream measurements in drainage basin of 78-126
Iola, Colo., stream measurements at..... 44-46
Iowa Hill road bridge, California, American River (North Fork) above, measurements of 158
Irish-American ditch, Nevada, measurements of 124
Iron Canyon, California, stream measurements at 137-141
Irrigation projects in western half of United States, location of, map showing 12
Isabella, Cal., stream measurements between Kernville and..... 162
Jackass Creek, California, measurements of 160
Jacks Valley Creek, Nevada, measurements of 126
Jacksonville, Cal., stream measurements at 160
Jacobs canal, Idaho, measurements of.. 211
James Canyon Creek, Nevada, measurements of 126
Jellys Ferry, California, stream measurements at 137-141
Julian's ranch, California, stream measurements at..... 135-137
Junction Valley, Utah, seepage in..... 94
water diverted for irrigation in..... 92, 94
water entering 90, 94
water leaving 93-94
Kaweah River, California, miscellaneous measurements of 161
Kern River, California, irrigation from. 129
measurements of 154-155, 162
Kern River, Little, California, measurements of 162
Page.
Kern River Power Company, Cal., powerhouse of, Kern River at, measurements of 162
Kernville, Cal., stream measurements between Isabella and..... 162
King City, Cal., stream measurements near 166-167
King River, measurements of, at Kingsburg, Cal..... 149
measurements of, near Sanger, Cal. 150-151
miscellaneous measurements of 160
source and regimen of 128-129
Kings Canyon Creek, Nevada, measurements of 126
Kingsburg, Cal., stream measurements at..... 149, 161
Kingsburg canal, California, measurements of 161
Kingsbury Creek, Nevada, measurements of 126
Kiona, Wash., stream measurements at. 186-188
Knights Ferry, Cal., stream measurements below 159
Lagrange, Cal., stream measurements at..... 142-146, 160
Lagrange dam, California, stream measurements above 160
Lagrange ditch, California, measurements of 160
Lake Creek, Utah, measurements of..... 58-61
Lake Eleanor trail crossing, California, stream measurements below. 159
Lake Fork, Colorado, measurements of.. 77
Lakeport, Cal., evaporation at..... 132
Lamburger & Ryan ditch, Idaho, measurements of 211
Lancha Plana dam, California, stream measurements below..... 159
Laurel Creek, California, stream measurements between Ockenden and 160
Lathos Creek, Colorado, measurements of 77
Leland, Utah, stream measurements near 52-55
Lemon Cove, Cal., stream measurements between Three Rivers and... 161
Lippincott, J. B., work done by..... 16
Livingstone, Ariz., Salt River near, measurements of 25-29
Tonto Creek near, measurements of.. 29-32
Little Grass Valley, California, stream measurements in 157
Logan, Utah, stream measurements at.. 86-87
Logan River, Utah, measurements of.... 86-87
Long Valley Creek, measurements of, at Diamond Valley, California 125
measurements of, at Long Valley reservoir site, Nevada..... 125
above Springmeyer's ranch, Nevada..... 125
Long Valley reservoir site, Nevada, stream measurements at dam at..... 125
Los Pinos River, Colorado, location of.... 16
measurements of 39-40

Page.
Love Creek, California, measurements below junction of Moran Creek and 159
Lower lake, California, stream measurements at 130-132
Lytle Creek, California, measurements of 179
McCarty canal, Idaho, measurements of. 211
McCloud River, California, measurements of 156
McCoy's ranch, Colorado, stream measurements near 77
McDowell, Ariz., Salt River at, measurements of 23-25
Verde River near, measurements of.. 21-23
McFarlands bridge, California, Tule River at, measurements of.... 161
Main, Mont., stream measurements at. 226-228
Mancos, Colo., stream measurements at.. 77
Mancos River, Colorado, measurements of 77
Maplevalley, Wash., stream measurements near 218-219
Marble Fork, Kaweah River, California, measurements of 161
Marys River, Nevada, measurements of. 106
Marysvale Valley, Utah, water diverted for irrigation in 92, 94
water entering 90, 94
water leaving 93-94
seepage in 94
Marysville, Idaho, stream measurements near 215-216
Mason Slough, Nevada, measurements of. 125
Mason Valley, Nevada, stream measurements in 125
Mason's ranch, Nevada, stream measurements at 101-103
Matilija, Cal., Ventura River at, measurements of 177
Meadow View Hotel, California, stream measurements near 157
Meeker, Colo., stream measurements at.. 50-52
Meeks & Daley ditch, California, natural flow in 180
Mendote, Cal., stream measurements at. 160
Merced Falls, Cal., stream measurements above 147-148
stream measurements near 160
Merced River, California, drainage area of 128
measurements of 147-148, 160
Meritt ditch, Nevada, measurements of.. 125
Middle Fork, Kaweah River, California, measurements above 161
Middle Fork, San Joaquin River, California, measurements of 160
Middleton, Idaho, waste east of, measurements of 211
Middleton Canal Company canal, Idaho, measurements of 211
Middleton Mill Slough, Idaho, measurements of 211
Middleton Water Company canal, Idaho, measurements of 211
Mill Creek, California, measurements of. 159, 179
Miller & Lux canal, California, measurements of ..... [illegible]
Miller Bridge, California, San Joaquin River above, measurements [illegible]
Milton (now Angels) ditch, California, measurements of ..... [illegible]
Minidoka, Idaho, stream measurements near ..... [illegible]
Mink, Cal., stream measurements near [illegible]
Missoula, Mont., stream measurements at ..... [illegible]
Missoula River, Montana, measurements of ..... [illegible]
Mohave River, California, measurements of ..... [illegible]
Mokelumne ditch, California, measurements of ..... [illegible]
Mokelumne River, California, miscellaneous measurements of ..... [illegible]
Mono, Cal., stream measurements between Pine Ridge and ..... [illegible]
Mono Creek, California, measurements of ..... [illegible]
Montgomery Ferry, Idaho, stream measurements at ..... [illegible]
Moran Creek, California, measurements below junction of Love Creek and ..... [illegible]
Motts Creek, Nevada, measurements of.. [illegible]
Mount Whitney Power Company's flume, California, measurements of.. [illegible]
Muldoon ditch, Nevada, measurements of ..... [illegible]
Murphy ditch, lower, California, measurements of ..... [illegible]
Murphy ditch, upper, California, measurements of ..... [illegible]
Mystic, Cal., stream measurements at.. [illegible]
Naches River, Washington, measurements of ..... [illegible]
Natoma ditch, California, measurements of ..... [illegible]
Negro Hill canal, California, measurements of ..... [illegible]
Nelson Creek, California, measurements above mouth of ..... [illegible]
Nelsons, Cal., stream measurements between Indian Reservation and. [illegible]
Nevada-California State line, stream measurements at ..... [illegible]
New York canal, Idaho, measurements of ..... [illegible]
Newell, F. H., letter of transmittal by... [illegible]
Nordyke, Nev., stream measurements at. [illegible]
North Bloomfield ditch, California, measurements of ..... [illegible]
North Columbia, Cal., stream measurements at ..... [illegible]
North Fork canal (American River), California, measurements of ..... [illegible]
North Yakima, Wash., Naches River near, measurements of ..... [illegible]
Tieton River near, measurements of ..... [illegible]
Northbend, Wash., stream measurements near ..... [illegible]

Page
ıdale, Cal., stream measurements at.. 159
ıenden, Cal., stream measurements between Laurel Creek and..... 160
ı Mission bridge, California, San Gabriel River at, measurements of..... 177
a, Idaho, stream measurements at and near..... 215-216
ıana, Nev., stream measurements near..... 96-98
ıville, Cal., stream measurements at. 133-135
ıerton, Cal., stream measurements near..... 121-122
ıcific, Cal., stream measurements near. 158
ıdermo canal, California, measurements of..... 157
ıalisade, Nev., Humboldt River at, measurements of..... 100
Pine Creek at, measurements of..... 101
alisades, Colo., stream measurements near..... 46-48
'alouse River, Washington, measurements of..... 203-205
'anguitch Valley, Utah, seepage in..... 94
water diverted for irrigation in..... 92, 94
water entering..... 90, 94
water leaving..... 93, 94
Parks Creek, Nevada, measurements of 126
Parrotts Ferry, California, stream measurements at..... 159
Paynne canal, Idaho, measurements of.. 211
Pecks Bridge, California, stream measurements at..... 156
Pedrolis, Nev., stream measurements at. 126
Pedrolis ditch, Nevada, measurements of. 126
Penault canal or Goodwin Mill, Idaho, measurements of..... 211
Petersons Creek, California, measurements of..... 125
Pettitts ranch, California, Arroyo Seco at, measurements of..... 163-165
Phyllis canal, Idaho, measurements of... 211
Pine Creek, Colorado, measurements of.. 77
Pine Creek, Nevada, measurements of... 101
Pine Ridge, Cal., stream measurements between Mono and..... 160
Piney Creek, Colorado, Grand River near, measurements of..... 77
Pioneer canal, California, measurements of..... 161
Pioneer canal, Idaho, measurements of.. 211
Pitt dam, Nevada, stream measurements below..... 124
Pitt River, California, miscellaneous measurements of..... 156
Placerville, Cal., stream measurements near..... 158
Placerville ditch, California, measurements of..... 158
Pleasant Valley, Cal., stream measurements at..... 157
Plunge Creek, California, measurements of..... 179
Pollasky, Cal., stream measurements at. 160
Portersville, Cal., stream measurements at and near..... 151-153, 161
Prattville, Cal., stream measurements at. 157

Page.
Price road bridge, Utah, Duchesne River at, measurements of..... 55-58
Prosser Creek, California, measurements of..... 122
Provo, Utah, stream measurements near. 88
Provo River, Utah, measurements of.... 88
Puget Sound, drainage basin of, stream measurements in..... 216-224
Quincy, Cal., stream measurements near. 157
Rancheria Creek, California, measurements of..... 159
Ranchero & Bloomington ditch, California, developed water in..... 180
Red Bluff, Cal., stream measurements near..... 137-141
Red Lake River, Minnesota, measurements of..... 234-235
Red Mountain, California, stream measurements at..... 150-151, 161
Red River, measurements of, at Emerson, Canada..... 233-234
measurements of, at Fargo, N. Dak. 237-238
at Grand Forks, N. Dak..... 235-236
Redlands canal, California, measurements of..... 179
Redlands tunnel, California, stream measurements at..... 179
Resident hydrographers in various States and Territories..... 14-15
Rialto canal, California, measurements above intake of..... 179
measurements at, weir headworks of. 179
Ridenbaugh canal, Idaho, measurements of..... 211
Rincon, Cal., seepage at..... 181
River stations and principal irrigation projects in western half of United States, location of, map showing..... 12
River stations in eastern half of United States, location of, map showing..... 13
Riverside, West, pumping plant, Cal., developed water from..... 180
Riverside canal, California, seepage of... 181
Riverside canal, Idaho, measurements of. 211
Riverside Narrows, California, seepage at and above..... 181
Riverside Water Company's, California, flume of, seepage in..... 181
mill flume of, natural flow in..... 180
mill pump of, developed water from. 180
upper canal of, natural flow and developed water in..... 180
Riverton, Cal., stone bridge at, stream measurements above..... 158
Roaring River, California, measurements of..... 161
Robe, Wash., stream measurements near..... 223-224
Robinson Creek, California, measurements of..... 125
Robinsons Box, Nevada, stream measurements at..... 126
Robinsons Ferry, California, stream measurements at..... 159
Rock Creek, Colorado, measurements of. 77

Page.
Rodenbah's ranch, Nevada, stream measurements at 111-113
Rodgers ditch, Nevada, measurements of 124
Rogers pumping plant, California, developed water from 180
Ross ranch, Nevada, stream measurements at 107-108
Rossi logging canal, Idaho, measurements of 211
Rossi waste, Idaho, measurements of 211
Rubicon River, California, measurements of 158
Rubidoux canal, California, seepage of .. 181
Sacramento, Cal., stream measurements at 15
Sacramento River, California, measurements of 137-141, 156-157
source and course of 127
St. Mary, Mont., St. Mary River near, measurements of 231-233
Swiftcurrent Creek near, measurements of 229-231
St. Mary River, measurements of, at Main, Mont 226-228
measurements of, near Cardston, Canada 225-226
near St. Mary, Mont 231-233
Salmon Creek, California, measurements of 162
Salmon Falls, Cal., dam at, stream measurements below 158
Salt River, Arizona, measurements of, at McDowell, Ariz 23-25
measurements of, near Livingstone, Ariz 25-29
source and course of 16
San Antonio Creek, California, measurements of 159, 178-179
San Antonio tunnel, California, stream measurements at 179
San Bernardino Valley, California, developed water in, compared with natural flow of Santa Ana River 180
seepage in 181
San Carlos, Ariz., stream measurements at 32-35
San Francisco Bay, stream measurements in drainage basin of 127-162
San Gabriel canals, California, measurements of 167-171
San Gabriel Electric Company's power house, California, concrete weir basin at, measurements at 178
San Gabriel River, California, miscellaneous measurements of 177
San Joaquin power house, California, stream measurements near ... 160
San Joaquin River, California, measurements of 155-156, 160, 167-171
valley of, features in 127
San Lorenzo Creek, California, measurements of 166-167
San Juan River, source and course of 16
San Pitch River, Utah, measurements of 94-96
Sand box weir, California, Redlands canal at, measurements of ..... [illegible]
Sanger, Cal., stream measurements near ..... [illegible]
Santa Ana canal, California, measurements of ..... [illegible]
Santa Ana River, California, measurements of ..... 171-175 [illegible]
natural flow, compared with developed water in San Bernardino Valley ..... [illegible]
seepage along ..... [illegible]
Santa Ana River flume, California, Riverside pumping plant No. 1, developed water from ..... [illegible]
Riverside pumping plant No. 2, developed water from ..... [illegible]
Sebree canal, Idaho, measurements of ... [illegible]
Sebree River, Idaho, measurements of ... [illegible]
Sediment carried by Colorado River amount of ..... [illegible]
Seibenberg Slough, Idaho, measurements of ..... [illegible]
Sequoia National Park line, California, stream measurements above [illegible]
Settlers canal, Idaho, measurements of [illegible]
Seventy-six canal, California, measurements of ..... [illegible]
Sevier River, Utah, measurements of ... [illegible]
seepage measurements in basin of .... [illegible]
Sheep Creek, California, measurements of ..... [illegible]
Sheridan Creek, Nevada, measurements of ..... [illegible]
Sheyenne River, North Dakota, measurements of ..... [illegible]
Shoshone Falls, Idaho, stream measurements between the Cedars and ..... [illegible]
stream measurements between Twin Falls and ..... [illegible]
Silver Creek, California, measurements of [illegible]
Silverthorn Ferry, California, measurements of ..... [illegible]
Simpsons Meadows, California, stream measurements below trail to [illegible]
Skykomish River (South Fork), Washington, measurements of .... [illegible]
Slanson well, California, discharge of .... [illegible]
Slover Mountain, California, seepage below ..... [illegible]
Smartsville, Cal., stream measurements at ..... [illegible]
Smiths Valley, Nevada, stream measurements in lower end of ..... [illegible]
Snake River, Colorado, measurements of [illegible]
Snake River, Idaho, measurements of [illegible]
Snelling, Cal., stream measurements below ..... [illegible]
Snoqualmie Falls, Washington, stream measurements above ..... [illegible]
Snoqualmie River, Washington, measurements of ..... [illegible]
Soda Creek, Upper, California, stream measurements at ..... [illegible]
Soldiers Camp, California, stream measurements between Tar Gap and [illegible]

Page.
ldiers' Home, Idaho, stream measurements above 211
ledad, Cal., stream measurements near 163-165
mers Creek, California, measurements of 125
ulsby ditch, California, measurements of 159
uth Fork (American River), California, measurements above mouth of 158
uth Fork bridge, California, Mokelumne ditch below, measurements of 158
uth Riverside ditch, Nevada, measurements of 124
outh Yuba Water Company, California, dam of, stream measurements below 158
new power canal of, measurements of 158
outhwest ditch, Nevada, measurements of 124
panish Creek, California, measurements of 157
pencer, Colo., stream measurements between Dubois, Colo., and 77
Spokane, Wash., stream measurements at 196-198
Spokane River, Washington, measurements of 196-198
Spring Creek, Colorado, measurements of 77
Spring Hill weir, California, stream measurements at 178
Springmeyer's ranch, Nevada, stream measurements above 125
Squaw Creek, California, measurements of 156
Squaw Creek bridge, California, stream measurements at 156
Stafford & Neil ditch, California, measurements of 162
Stafford ditch, lower, California, measurements of 162
Standard dam, California, stream measurements above 125
Standard ditch, California, flume No. 59 of, measurements of 158
Standard Electric Company's power house, California, stream measurements above 159
Standifer ditch, California, measurements of 177
Stanislaus River, California, miscellaneous measurements of 159
Stanislaus Water Company's canal, California, measurements below intake of 159
measurements in flume No. 3 of 159
Star, Idaho, stream measurements below. 211
Star bridge, Idaho, Boise River at, measurements of 211
Steamboat Springs, Colo., stream measurements at 77
Stilaguamish River, Washington, measurements of 223-224
Stony Creek, California, drainage area and course of 128
measurements of 135-137
Strahorn canal, Idaho, measurements of. 211
Stream measurements, publications containing (list) 12-13
Strosnider's ranch, Nevada, stream measurements at 125
Sumner ditch, California, measurements of 162
Susan River, California, measurements of 123-124
Susanville, Cal., stream measurements near 123-124
Swamp ditch, California, natural flow in. 180
Swanger Creek, California, measurements of 125
Sweetwater Creek, Nevada, measurements of 125
Swiftcurrent Creek, Montana, measurements of 229-231
Tahoe, Cal., stream measurements at.. 115-117
Tar Gap, Cal., stream measurements between Soldiers Camp and .. 161
Taylor River, Colorado, measurements of. 77
Tenaya River, California, measurements of 160
Tenmile Creek, Idaho, waste in, measurements of 211
Threerivers, Cal., stream measurements above 161
stream measurements between Lemon Cove and 161
Thorn ditch, Nevada, measurements of.. 126
Thurston ditch, California, measurements of 162
Tieton River, Washington, measurements of 194-196
Till-Till Creek, California, measurements of 159
Tobias Creek, California, measurements of Kern River between Salmon Creek and 162
Tonto Creek, Arizona, measurements of. 29-32
Trimmer Springs, Cal., stream measurements at 161
Truckee, Cal., stream measurements near 123
Truckee River, measurements of, at Nevada-California State line... 119-121
measurements of, at Tahoe, Cal.... 115-117
at Vista, Nev 117-119
near Mystic, Cal 119-121
Trull, Colo., stream measurements at.... 77
Tule River, California, drainage area of and irrigation from 129
measurements of 151-153, 161-162
Tunnel ditch, Nevada, measurements of 125
Tuolumne Electric Power Company's canal, California, measurements near intake of 159
Tuolumne Meadows, Cal., lower end of, stream measurements at 159
Tuolumne River, California, measurements of 142 146, 159-160
source and drainage basin of 128
Turlock canal, California, measurements of 144-146, 160
Twin Creek, East, California, measurements of 179

Page.
Twin Creek, West, California, measurements of 179
Twin Falls, Idaho, stream measurements between Shoshone Falls and.. 216
Twin Lakes, Cal., stream measurements below 125
Uinta, Utah, stream measurements near. 87
Uinta River, measurements of, at Fort Duchesne, Utah 61-65
measurements of, near Leland, Utah. 52-55
near Whiterocks, Utah 65-68
Umatilla River, Oregon, measurements of 183-185
Uncompahgre River, Colorado, measurements of 77
Union canal, Idaho, measurements of 211
Union canal, Nevada, measurements of .. 124
Union Gap, Wash., stream measurements at 188-190
Upper Bairds station, Cal., stream measurements at 156
Vanardsdale Clubhouse, California, stream measurements at 156
Ventura River, California, miscellaneous measurements of 177
Verde River, Arizona, measurements of . 21-23
Vernal, Utah, stream measurements near 71-73
Victorville, Cal., stream measurements at 175-177
Vista, Nev., stream measurements at.. 117-119
Wabuska, Nev., stream measurements near 106-107
Wagon bridge, Utah, Lake Creek (near mouth) at, measurements of.. 58-61
Walker River, measurements of, at Nordyke, Nev 125
measurements of, near Wabuska, Nev 106-107
miscellaneous measurements in basin of 125
Walker River (East Fork), Nevada, measurements of 107-108
Walker River (West Fork), California, measurements of 108
Walker River, East, California, miscellaneous measurements of 125
Walker River, East, Nevada, miscellaneous measurements of 125
Walker River, West, California, miscellaneous measurements of 125
Walsh ditch, measurements of 126
Ward & Warren ditch, California, natural flow and developed water in 180
Wards Ferry, Cal., stream measurements at 159
Warmsprings, Cal., stream measurements at 171-175
Water company's ditch, Nevada, measurements of 123
Wawona, Cal., stream measurements at. 160
Weber River, Utah, measurements of... 87
Webster's ranch, Nevada, stream measurements at 125
Weiser, Idaho, stream measurements near ..... [illegible]
Weiser River, Idaho, measurements of. [illegible]
Weldon crossroads, California, stream measurements above ..... [illegible]
West Branch (Feather River), California, measurements of ..... [illegible]
West Point, Cal., stream measurements near ..... [illegible]
West Riverside Bridge, California, seepage at ..... [illegible]
Wheaton's, Tom, ranch, California stream measurements at ..... [illegible]
White River, measurements of, at Buckley, Wash ..... [illegible]
measurements of, at Meeker, Colo.... [illegible]
Whiterocks, Utah, Uinta River near, measurements of ..... [illegible]
Whiterocks River near, measurements of ..... [illegible]
Whiterocks River, Utah, measurements of ..... [illegible]
Whitewater, Colo., stream measurements at ..... [illegible]
Williams Fork, Colorado, measurements of ..... [illegible]
Willow Creek, Idaho, waste from, measurements of ..... [illegible]
Wilsons Ford, Nevada, stream measurements at ..... [illegible]
Wilsons mill, Idaho, Fall River at, measurements of ..... [illegible]
Woodbridge, Cal., stream measurements at ..... [illegible]
Woodbridge canal, California, measurements of ..... [illegible]
Woodfords, Cal., stream measurements at ..... [illegible]
Woodlands, Cal., stream measurements near ..... [illegible]
Woods Creek, California, measurements of ..... [illegible]
Yakima River, measurements of, at Kiona, Wash ..... [illegible]
measurements of, at Union Gap, Wash ..... [illegible]
Yampa River, Colorado, character, source, and course of ..... [illegible]
measurements of, at Craig, Colo ..... [illegible]
at Hayden, Colo ..... [illegible]
at Steamboat Springs, Colo ..... [illegible]
Yankee Hill Bridge, California, West Branch of Feather River above, measurements of ..... [illegible]
Yerington, Nev., stream measurements near ..... [illegible]
Yolo Bridge, California, Cache Creek at, measurements of ..... [illegible]
Yosemite Valley, California, stream measurements of ..... [illegible]
Yuba River, California, measurements of [illegible]
Yuma, Ariz., pumping plants deriving water from Colorado River at. [illegible]
stream measurements at ..... [illegible]

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Author.

Newell, F[rederick] H[aynes].

. . . Report of progress of stream measurements for the calendar year 1902, by F. H. Newell; pt. IV—Interior basin, Pacific coast, and Hudson Bay drainage. Washington, Gov't print. off., 1903.

250 p., 1 l. fig. 23½cm. (U. S. Geological survey. Water-supply and irrigation paper no. 85.)

Subject series P, Hydrographic progress reports, 23.

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Water-supply and irrigation papers

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STORAGE RESERVOIRS

ON

STONY CREEK, CALIFORNIA

BY

BURT COLE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

CONTENTS.

	Page.
Letter of transmittal	7
Introduction by J. B. Lippincott	9
Scope and organization of work	9
Water supply of Sacramento Valley	10
Farming conditions	12
Population	13
Central irrigation district	14
Possible reorganization of Central irrigation district	19
Topography	20
Proposed Stony Creek Forest Reserve	20
Precipitation and climate	23
Run-off	32
Silt	35
Storage possibilities	36
Grindstone Creek	36
Salt Creek	36
North Fork of Stony Creek	36
Briscoe Creek	37
Little Stony Creek; East Park reservoir site	47
Mill site; reservoir site	56
Summary	59
Conclusions	60

ILLUSTRATIONS.

		Page.
PLATE I.	Orange tree, Willows, Cal	10
II.	*A*, Sacramento Valley wheat farm near Willows; *B*, Typical ranch house of wheat farm near Willows	12
III.	Sacramento River opposite Willows	14
IV.	*A*, Central Irrigation District canal opposite Jacinto; *B*, Central Irrigation District canal near St. Johns	16
V.	*A*, Black Butte; *B*, Stony Creek gaging station	22
VI.	Briscoe Creek dam site	38
VII.	Briscoe Creek reservoir site	40
VIII.	Briscoe Creek dam site abutment	42
IX.	*A*, East Park dam site on Little Stony Creek; *B*, West half of East Park reservoir site	46
X.	East Park reservoir site	48
XI.	*A*, Conglomerate at East Park; *B*, Mill Site dam site on Stony Creek	50
XII.	Mill Site reservoir site	52
XIII.	Plan of concrete dam, East Park dam site	54
XIV.	Mill Site dam site, rock-filled dam	56
XV.	Plan of Mill Site dam	56
XVI.	Alfalfa field, Brown's ranch, Stony Creek Valley	58
FIG. 1.	Mean monthly precipitation at Woodlands, Fouts Springs, and Red Bluff	27
2.	Briscoe dam site, Stony Creek	37
3.	Capacity curve, Briscoe reservoir	38
4.	Plan of concrete dam, Briscoe reservoir	38
5.	Section of concrete dam, Briscoe reservoir	39
6.	Plan of spillway, Briscoe reservoir	40
7.	Section of spillway, Briscoe reservoir	40
8.	Plan of concrete overflow dam, Briscoe reservoir	42
9.	Elevation of concrete overflow dam, Briscoe reservoir	43
10.	Cross section of concrete overflow dam, Briscoe reservoir	43
11.	Plan of subsidiary earth dam, Briscoe reservoir	44
12.	Cross section of subsidiary earth dam, Briscoe reservoir	44
13.	Plan of rock-filled dam, Briscoe dam site	45
14.	Section of rock-filled dam, Briscoe dam site	45
15.	Plan of spillway, Briscoe dam site	46
16.	Section of spillway, Briscoe dam site	46
17.	Capacity curve, East Park reservoir	48
18.	East Park dam site	49
19.	Maximum cross section of concrete dam, East Park dam site	50
20.	Profile of dam site, East Park dam site	50
21.	Outlet tunnel, East Park dam site	51
22.	Profile of spillway, concrete dam, East Park dam site	51

Page

FIG. 23. Cross section of spillway, concrete dam, East Park dam site
24. Plan of rock-filled dam, East Park dam site
25. Maximum cross section, rock-filled dam, East Park dam site
26. Downstream elevation, rock-filled dam, East Park dam site
27. Upstream elevation, rock-filled dam, East Park dam site
28. Detail of plank face, rock-filled dam, East Park dam site
29. Plan showing relative position of waste way, rock-filled dam, East Park dam site
30. Cross section of waste way, rock-filled dam, East Park dam site
31. Plan of waste way, rock-filled dam, East Park dam site
32. Profile of waste way, rock-filled dam, East Park dam site
33. Outlet of tunnel, rock-filled dam, East Park dam site
34. Plan of valves, rock-filled dam, East Park dam site
35. Tunnel cross section, rock-filled dam, East Park dam site
36. Section of Mill Site dam
37. Section of spillway, Mill Site dam
38. Capacity curve, Mill Site reservoir

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., February 21, 1903.

SIR: I have the honor to transmit herewith manuscript of a paper by Mr. Burt Cole, entitled "Storage Reservoirs of Stony Creek, California," and request that it be published in the series of Water-Supply and Irrigation Papers. The paper treats of the possibilities of reclaiming by irrigation large areas of land in the valley of Stony Creek, a tributary of the Sacramento River, and on the west side of the Sacramento Valley, which have been cultivated by dry farming, but on which irrigation may apparently be introduced with much advantage.

Very respectfully, F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

STORAGE RESERVOIRS ON STONY CREEK, CALIFORNIA.

By BURT COLE.

INTRODUCTION.

By J. B. LIPPINCOTT.

SCOPE AND ORGANIZATION OF WORK.

Recognizing the fact that the general and permanent prosperity of California is largely dependent upon successful agricultural development, and furthermore that in the great central valleys of the State farming without irrigation has caused, during the last decade, a decrease in land values, as well as in population, it was deemed desirable to investigate the possibilities of irrigation development in certain typical interior districts of the State. In the above connection the California Water and Forest Association requested the United States Geological Survey to make a study of Glenn County to ascertain if suitable reservoir sites could be found on Stony Creek, so that the waters of that stream could be put upon the higher and warmer marginal lands on the western side of the Sacramento Valley. Willows is the county seat of Glenn County, and the chamber of commerce of this town, through the Water and Forest Association, contributed $250 additional toward defraying the expenses of this study. The field work has been entirely under the direction of the Hydrographic Branch of the Geological Survey, and the greater part of the expense has been borne by that Survey.

The greater portion of this investigation has been devoted to the drainage basin of Stony Creek. However, by far the greatest natural water supply for Glenn and neighboring counties is the Sacramento River, which is the largest navigable river of the State, and forms the eastern boundary of Glenn County. The difficulty of using this river lies in the expense and magnitude of works necessary for its diversion, especially if its waters are to be put upon the higher valley lands. The interference with navigation by the diversion of water from the river during its low stage is a serious question. It is considered pertinent, however, to briefly refer to the Sacramento River and its possible utilization.

WATER SUPPLY OF SACRAMENTO VALLEY.

The seasonal rotation in the Sacramento Valley much resembles that in the southern valleys of the State situated between the Sierra Nevada and the Coast Range. There is more rain in the Sacramento Valley, but it falls in the same months. There is a distinct dry summer extending from April until October. In midsummer the temperature is at times as high as 114°, and the relative humidity is low, ranging from 10 to 20 per cent. In the other half of the year the rainfall ranges from 25.56 inches at Red Bluff, at the head of the Sacramento Valley, to 18.19 inches at Woodland, in Yolo County. The minimum temperature recorded by the United States Weather Bureau at Red Bluff since 1878 is 18°. These temperatures permit the growth of all of the products of the State. A compilation of physical statistics for Red Bluff by Mr. Maurice Connell, observer for the United States Weather Bureau, is given in this report. They show in detail the conditions here referred to.

Surrounding Sacramento Valley on the north, east, and west are high ranges of mountains culminating in Mount Shasta, at the northern apex of the valley, with an elevation of 14,380 feet. Upon the crest of these ranges, the Sierra Nevada on the east and the Coast Range on the west, the precipitation is much greater and occurs usually in the form of snow, which remains at the higher altitudes until melted by the summer sun. As the mountains are higher to the north and east of the valley than to the west, the precipitation is greater there, the temperature is lower, and the snow remains unmelted until later in the summer. The stream conditions resulting from these physical conditions may readily be inferred. From the higher sierras the creeks begin to rise with the fall rains, and the precipitation in the foothills causes them to maintain their flow throughout the winter. Under normal conditions, however, they reach stages of maximum discharge in the spring and early summer, when the snows at the higher levels are melting. They reach their lowest stages in September. On the western side of the valley the streams issuing from the Coast Range, to which class Stony Creek belongs, flow from lower and warmer levels. Consequently the precipitation is more often in the form of rain and the snow is more quickly melted. The resulting stream flow, therefore, is more irregular and the maximum periods of flow are in winter and early spring. These Coast Range streams are reduced to very low discharge throughout the summer months, and their proper utilization is largely dependent upon the construction of reservoirs for the conservation of the winter water. There is therefore a cool, wet winter in the valley, followed by a hot, dry summer. The Sacramento and its eastern tributaries are strong streams during the winter, spring, and early summer, and have relatively low discharges in September and October, while the western tributaries are normally high in winter and early spring and almost dry in the summer. These conditions not only demand the irrigation

ORANGE TREE, WILLOWS, CAL.

: the valley, but furnish the opportunity therefor. Tables of dis-
ıarge of the Sacramento River and of Stony Creek are made a part
f this report and illustrate the above statement.

The higher marginal valley lands are better drained and warmer
ıan the low lands. They are not so well adapted to the growth of
rain, as the soil is not so strong, but it is believed that with irrigation
hey would be among the finest fruit lands of the State, capable of
roducing the olive, vine, and orange.

The valley of the Po, in northern Italy, is the greatest artificially
vatered district of Europe. In this region irrigation has been prac-
iced continuously for over one thousand years. The values of water
ınd of irrigated lands have continually increased, and to-day it stands
ıs an example of most intensive cultivation, supporting 391 persons
per square mile in the irrigated district.

The following interesting comparison may be made between the
climatic conditions of Milan, in the heart of this district, and those
in the upper Sacramento Valley. R. Baird Smith, lieutenant of
engineers, British service, in a work entitled "Italian Irrigation," is
the authority for the statements on Italian irrigation. The record of
rainfall and temperature for Milan was obtained from the United
States Weather Bureau. It probably extends back into the eighteenth
century. For monthly maximum and minimum records at the head
of the Sacramento Valley, see the Red Bluff record given later in this
report.

Comparison of climatic conditions in Sacramento Valley and in northern Italy.

Month.	Rainfall.		Temperature.			
	Woodlands, Cal.	Milan, Lombardy.	Woodlands, Cal., Mean.	Milan, Lombardy.		
				Max.	Min.	Mean.
	Inches.	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*
January	3.67	2.28	42.6	55	7	33
February	2.56	2.34	45.5	71	19	38
March	2.72	2.60	48.9	74	21	46
April	1.75	3.59	55.5	82	27	54
May	.85	4.06	62.1	91	39	62
June	.12	3.30	70.1	97	48	70
July	.00	2.92	77.9	99	54	74
August	.02	3.66	76.1	95	53	72
September	.25	3.82	68.6	91	46	65
October	.92	4.93	60.4	78	33	55
November	2.01	4.22	50.4	63	23	43
December	3.42	2.87	43.5	61	10	36
Mean annual	18.25	40.59	58.5	99	7	54

The minimum temperature at Woodlands is not available. The lowest temperature recorded at Red Bluff by the Weather Bureau is 18° above zero.

It will be noted that there is double the rainfall in Lombardy that there is in Glenn County, and a large portion of it occurs in the summer, yet irrigation is accepted as decidedly profitable and water rights are increasing in value. This being true, irrigation certainly should be of marked benefit in the Sacramento Valley.

FARMING CONDITIONS.

Glenn County, lying in the upper portion of the Sacramento Valley and principally upon the western side of the Sacramento River, has so many natural advantages that if its valleys were divided into small farms and irrigated it probably could be made one of the most productive and densely populated agricultural counties in the State of California.

At present the farming land is almost wholly given up to the dry farming of wheat. This practice has been followed for years, until to-day the land, having annually surrendered its nutritive elements without fertilization, is deteriorating for this crop. This condition, coupled with the low prices obtained for the product during recent years, has resulted in a concentrated landholding, with a resulting decrease of population, large areas of wheat being farmed with greater economy than small ones. This is brought forcibly to the attention of one traveling over the roads in the great valley district. Numerous small bunches of trees mark the points where once stood a house, the home of a small farmer. To-day these families are scattered, and the small ranch is only a small fraction in a great farm of perhaps 10,000 to 20,000 acres, owned by one person and farmed by a drifting population employed only during the planting and harvesting season, and having no interest in the welfare of the county except in obtaining a few weeks' wages, which may or may not be spent in the neighboring towns.

Wheat farming, in spite of the fact that it is carried on by means of modern machinery, with perfect organization, and on a large scale, has not of late been a paying investment in Glenn and adjoining counties.

The climate of this valley is very similar to that of the southern counties of the State. Orange, lemon, and lime trees were seen in various parts of the plains, showing no signs of having been injured by frost. The yield is not large, owing to the fact that the trees have been allowed to grow usually as isolated garden shrubbery, receiving little care except perhaps an occasional watering. With irrigation and scientific care, Glenn County could become the home of numerous small farmers; the population of towns and country would be increased, and a thriving community would exist in the present sparsely settled region.

A. SACRAMENTO VALLEY WHEAT FARM NEAR WILLOWS.

B. TYPICAL RANCH HOUSE ON WHEAT FARM NEAR WILLOWS.

POPULATION.

Intensive farming by irrigation, especially the raising of fruit in alifornia, usually has led to the subdivision of large holdings, both ecause under these conditions large areas are not successfully han- ed and because increased land values, resulting from the supply of ater, is an inducement for the large landowner to sell.

The census of 1890 gives Colusa County, which at that time included lenn County, a population of 14,640, while the census of 1900 gives his same territory a population of 12,856 (Colusa 7,346, Glenn 5,510), nowing a decrease in the ten years of 12.8 per cent. According to he school census the number of school districts is 38 and the number f school children is 1,280. Of the latter 555 were in the towns, eaving 725 in the country, or only about 1 child to 2 square miles.

In 1891 Mr. William Hammond Hall, in an engineering report on he Central Irrigation District, situated in Glenn County and con- aining 156,550 acres of valley land, which was then attempting to onstruct irrigation works, states:

> There are 40 owners of over 1,000 acres each, holding an aggregate of about 89,000 cres, very materially more than half the acreage in this district. There are only bout 180 owners of farming lands altogether in it, so that the farm holdings all verage very nearly 870 acres in area, and the 140 smaller owners of, say 67,550 cres, have an average of 482 acres apiece. There are but few owners of less than 340 acres in the district, and by reason of the renting and share system still fewer persons who farm as low an acreage. The district has a stable voting population of about 400, of whom about 140 are residents of the towns of Maxwell and Williams. This leaves 260 voters on the farming lands proper, only 1.06 voters, or (taking the usual ratio of voters to population) about 5 persons to the square mile. Each farming landowner of the 180 (supposing all to be residents of the district) gets on with only 0.44 of a resident citizen hired man to help him farm his average holding of 870 acres.

The condition of the Central Irrigation District is practically the condition of the plains district of Glenn and Colusa counties.

Mr. W. H. Markham, deputy assessor of Glenn County, after an examination of the county records in 1900, reports that the average farm-land holding in the plains district, lands which could be irrigated, either from Stony Creek or from the ditches of the Central Irrigation District, is 1,595 acres. There are less than 40 owners of farming lands of 160 acres or less. It is not believed there are any farmers who cultivate less than 320 acres of land, it all being sown to wheat and barley.

For purposes of comparison between areas in California irrigated and those farmed dry, Riverside may be taken as a typical example of development by irrigation. Other similar districts could be referred to. About 13,500 acres are irrigated around Riverside, partly in young trees. It must be remembered that southern California has for seven years been suffering from an intense drought, much more severe than in the central portion of the State. Streams have failed,

but 500 wells have been sunk to supply these lands, from which water supply has been maintained in volume as large as during periods of abundant precipitation. These wells probably represent an investment of over half a million dollars, and are producing cubic feet of water per second, or enough to irrigate 20,000 acres of land. Starting with a sheep pasture, assessed under protest at cents per acre in 1870, this district now supports in comfort, if not luxury, about 10,000 inhabitants, or a citizen to every 1.3 acres irrigated (about 100 times as dense a population as the valley portion of Glenn County), and shipped over 4,000 carloads of citrus fruit during the season of 1900. The value of this crop was $150 per acre on the better irrigated area, and the output is rapidly increasing. The city of Riverside has 3 banks, 13 churches, and 8 schoolhouses. The post-office receipts in 1900 were $16,555. The amount of its bank deposits and assessed valuation make it perhaps the first city of its class in the United States.

From an agricultural standpoint the difference between northern and southern California is irrigation.

CENTRAL IRRIGATION DISTRICT.

In the course of the present work the constructed portion of the Central Irrigation canal was visited and inquiries were made as to its status. This canal was designed to take water from the Sacramento River near the northern boundary of Glenn County and irrigate 156,550 acres of fertile land in Glenn and Colusa counties. After expending $574,000 for construction and right of way, the district became involved in legal and financial difficulties growing out of the Wright act, under which it was organized, and work was discontinued. Both the constitutionality of the organic law and the organization under that law were contested by certain dissatisfied holders of large land areas in the proposed district. These parties objected to an organization based upon and controlled by a majority vote of the electors in the district, irrespective of their property holdings therein, the acceptance of water at uniform rates for all lands in the district being compulsory under the law. These objections have been brought forward in all the districts that have been organized under this statute.

No successful attempt has ever been made to collect either principal or interest on these bonds. The interest is increasing and the principal is becoming due. Much money has been spent by both "anti-irrigationists" and "irrigationists" in legal battles, but so far no definite result, except the stoppage of work for lack of funds, has been accomplished. The headworks of the canal were never built and no water has ever been delivered. The bonds are discredited in the financial market, and if the district should now be declared to be legal and the bonds properly issued it will force nearly every farmer in the district into bankruptcy, as it has been twelve years since the

U. S. GEOLOGICAL SURVEY

SACRAMENTO RIVER OPPOSITE WILLOWS.

onds were issued. The bondholders are getting no interest on their investment and the landholders are going on year after year summer allowing their land for wheat, and barely making interest on a low valuation of the land and property, while right at hand flows the Sacramento River, capable of turning this valley into as productive and densely populated a county as the irrigated portions of southern California counties.

The Sacramento River has an unfailing supply of water sufficient for all the needs of this section and of the lower valley lands, as is shown by the following table of flow, taken from the various reports of the United States Geological Survey.

Estimated monthly discharge of Sacramento River at Red Bluff.

[Drainage area, 9,356 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1895.						
January	123,000	15,220	47,267	2,906,320	5.05	5.82
February	65,600	13,860	26,792	1,487,940	2.86	2.98
March	85,360	15,220	32,517	1,999,418	3.48	4.01
April	33,880	26,670	29,566	1,759,300	3.16	3.53
May	48,600	16,840	30,238	1,859,250	3.23	3.73
June	18,600	9,040	12,764	759,510	1.36	1.52
July	9,040	6,150	7,235	444,863	.77	.89
August	6,150	5,990	6,057	372,436	.65	.75
September	10,820	5,830	6,321	376,106	.68	.75
October	6,285	5,910	5,989	368,261	.64	.74
November	6,690	5,910	6,046	359,792	.65	.71
December	36,880	6,150	10,095	620,760	1.08	1.24
The year	123,000	5,830	18,390	13,313,956	1.97	26.67

Estimated monthly discharge of Sacramento River at Jellys Ferry, Tehama County.

[Drainage area, 9,134 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1896.						
January	130,050	6,360	46,152	2,837,813	5.05	[illegible]
February	34,460	10,070	15,468	889,764	1.69	[illegible]
March	62,870	11,310	24,099	1,481,801	2.64	[illegible]
April	59,500	16,920	25,793	1,534,819	2.82	[illegible]
May	75,120	19,300	30,941	1,902,543	3.39	[illegible]
June	20,515	9,200	14,217	846,018	1.56	[illegible]
July	8,960	6,720	7,591	466,789	.83	[illegible]
August	6,720	6,180	6,394	393,201	.70	[illegible]
September	6,360	6,000	6,204	369,163	.68	[illegible]
October	8,000	6,000	6,163	378,960	.67	[illegible]
November	43,000	6,360	11,965	712,014	1.31	[illegible]
December	93,000	8,480	22,318	1,372,304	2.44	[illegible]
The year	130,050	6,000	18,109	13,185,189	1.98	[illegible]
1897.						
January	49,765	8,320	14,280	878,050	1.56	[illegible]
February	89,100	17,420	36,108	2,005,335	3.95	[illegible]
March	44,340	13,100	21,790	1,339,825	2.39	[illegible]
April	28,710	18,830	22,807	1,357,108	2.50	[illegible]
May	18,520	9,200	13,737	844,660	1.50	[illegible]
June	9,200	6,680	7,620	453,420	.83	[illegible]
July	6,550	5,120	5,699	350,420	.62	[illegible]
August	5,120	4,600	4,776	293,667	.52	[illegible]
September	4,600	4,600	4,600	273,718	.50	[illegible]
October	6,680	4,600	4,955	304,673	.54	[illegible]
November	8,600	5,120	5,590	332,627	.61	[illegible]
December	16,940	5,380	7,792	479,114	.85	[illegible]
The year	89,100	4,600	12,480	8,912,617	1.36	[illegible]
1898.						
January	6,525	5,835	6,120	376,307	.67	[illegible]
February	33,600	5,835	12,479	693,049	1.37	[illegible]
March	22,500	6,525	9,745	599,201	1.07	[illegible]
April	7,260	6,525	6,872	408,911	.75	[illegible]
May	10,800	5,375	6,632	407,789	.73	[illegible]
June	10,500	5,150	6,674	397,130	.73	[illegible]
July	5,150	4,475	4,700	288,994	.52	[illegible]

A. CENTRAL IRRIGATION DISTRICT CANAL OPPOSITE JACINTO.

B. CENTRAL IRRIGATION DISTRICT CANAL NEAR ST. JOHNS.

Estimated monthly discharge of Sacramento River at Jellys Ferry, Tehama County—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1898.						
August	4,475	4,250	4,276	262,923	0.47	0.54
September	4,475	4,250	4,280	254,677	.47	.53
October	4,925	4,475	4,631	284,751	.51	.59
November	6,892	4,475	4,785	284,727	.52	.58
December	5,950	4,700	4,991	306,887	.55	.63
The year	33,600	4,250	6,349	4,565,346	.70	9.38
1899.						
January	42,600	5,065	13,498	829,965	1.48	1.71
February	8,644	5,810	6,646	369,100	.73	.76
March	83,400	6,750	20,915	1,286,022	2.29	2.64
April	16,100	7,800	10,837	344,845	1.19	1.33
May	7,530	6,030	6,908	424,759	.76	.87
June	15,200	4,965	6,199	365,865	.68	.75
July	4,760	4,170	4,531	278,592	.50	.58
August	4,170	3,980	3,986	245,061	.44	.51
September	3,980	3,980	3,980	236,826	.44	.49
October	10,550	3,980	5,063	311,314	.55	.63
November	53,480	4,760	14,532	864,712	1.59	1.77
December	45,600	8,915	14,519	892,744	1.59	1.83
The year	83,400	3,980	9,301	6,752,805	1.02	13.87
1900.						
January	119,700	10,400	30,661	1,885,271	3.36	3.88
February	24,800	7,800	11,687	649,063	1.28	1.33
March	123,000	10,700	23,288	1,431,923	2.55	2.94
April	16,700	8,630	12,082	718,929	1.32	1.47
May	19,780	6,265	9,572	588,559	1.05	1.21
June	6,265	4,760	5,477	325,904	.60	.67
July	4,760	3,805	4,212	258,986	.46	.53
August	3,805	3,805	3,805	233,960	.42	.48
September	5,170	3,630	3,981	236,886	.44	.49
October	21,520	3,805	6,381	392,352	.70	.81
November	28,800	4,560	8,205	488,231	.90	1.00
December	80,100	6,030	15,553	956,317	1.70	1.96
The year	123,000	3,630	11,242	8,166,381	1.23	16.77

Estimated monthly discharge of Sacramento River at Jellys Ferry, Teha[illegible] County—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in [illegible]
1901.						
January	74,240	8,915	20,982	1,290,194	2.30	[illegible]
February	101,880	9,800	34,138	1,895,928	3.74	[illegible]
March	46,100	12,200	20,628	1,268,366	2.26	[illegible]
April	16,700	9,200	10,870	646,810	1.19	[illegible]
May	13,700	7,530	9,804	602,824	1.07	[illegible]
June	7,265	4,965	5,596	332,985	.61	[illegible]
July	4,760	3,980	4,365	268,393	.48	[illegible]
August	3,980	3,805	3,850	236,727	.42	[illegible]
September	5,380	3,630	3,922	233,375	.43	[illegible]
October	5,380	3,980	4,194	257,879	.46	[illegible]
November	44,100	4,360	7,745	460,859	.85	[illegible]
December	61,800	5,380	12,149	747,013	1.33	[illegible]
The year	101,880	3,630	11,521	8,241,353	1.26	[illegible]

Estimated monthly discharge of Sacramento River at Iron Canyon, Tehama County, Cal.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in [illegible]
1902.						
January [a]	6,750	4,760	5,376	330,557	0.59	[illegible]
February	151,320	5,660	69,153	3,840,563	7.44	[illegible]
March	61,700	14,150	27,371	1,682,977	2.94	[illegible]
April	53,800	14,150	21,992	1,308,615	2.37	[illegible]
May	24,460	10,150	17,803	1,094,663	1.92	[illegible]
June	13,450	7,060	9,998	594,922	1.08	[illegible]
July	7,060	5,880	6,192	380,731	.67	[illegible]
August	5,880	5,440	5,674	348,881	.61	[illegible]
September	5,220	5,000	5,007	297,938	.54	[illegible]
October	11,750	5,000	5,931	364,683	.64	[illegible]
November	118,200	5,660	19,834	1,180,204	2.13	[illegible]
December	39,100	8,110	17,506	1,076,402	1.88	[illegible]
The year	151,320	4,760	17,653	12,501,136	1.90	[illegible]

[a] Record of Sacramento at Jellys Ferry for January, 1902.

OSSIBLE REORGANIZATION OF CENTRAL IRRIGATION DISTRICT.

It is believed that the present time is auspicious for the carrying ıt of a reorganization plan. The question of the legality or illegality f the district's organization and bond issues has not yet been finally etermined, and neither party seems willing to push the matter to a nal issue.

If it is desirable to complete the works under private management, , is believed that the following plan might be carried out: The dis- rict to acquire what rights of way are necessary for the completion f the work. This probably can be done for about $30,000. The dis- rict should then deed to the bondholders its interest in the canal and ights of way and then disorganize, the bondholders canceling all ndebtedness against the land and furnishing the money to complete he works. The bondholders could then form an irrigation company ınd sell water at the low annual charge of $2 per acre, and thereby ›oth secure themselves and benefit the landowners. The land is 'ertile and suited to irrigation, and, owing to its closeness to market, ıhould be high priced and productive of handsome returns.[a]

TOPOGRAPHY.

The purpose of the present work was primarily to determine what could be done toward increasing the area of lands irrigated from the basin of Stony Creek. Stony Creek has a drainage area of about 760 square miles, as obtained from the best available Land-Office maps. While the crest of the watershed does not exceed about 6,700 feet in elevation, its proximity to the coast assures to it a substantial amount of rainfall. In the valleys the precipitation is 20 inches annually, while in the higher portions of the basin it probably reaches 40 inches. The summits are heavily covered with timber, much of it being commercial pine, spruce, and cedar. Several sawmills are located in the heart of this timbered area. Sheep, goats, and cattle are permitted freely to graze over the public lands, and numerous forest fires were observed, apparently coincident with the location of the grazing camps. It is currently stated that it is the common practice for sheep men to set fires upon leaving the ranges in the fall so that the underbrush and grasses can grow up young and tender for the next season. Cattlemen, finding heavily brushed areas over which it is difficult for the cattle to graze, are reported to set fires so as to make the country more open. The resulting damage does not apply alone to the brush-covered territory, as the fires, once started, keep on burning, unrestrained, into the timber belts, until a continued wind from the contrary direction causes the flames to back fire and extinguish

[a] Since the above was written (1901) a strong movement has been initiated to disorganize the district and to have a corporation complete the canal and distribute the water, the bonded debt to be assumed by the corporation.

themselves. If this forest destruction continues, it will cause the run-off to be more spasmodic, floods will closely follow each rain, and the amount of silt carried by the water will become so great that it will lead to the impairment of any reservoirs which might be constructed in this basin. It is strongly urged that the main portion of the drainage basin be set aside as a forest reserve, and that sheep and goat grazing be restricted or prohibited, and strong steps taken to prevent forest fires.

PROPOSED STONY CREEK FOREST RESERVE.

In respect to this matter the Sacramento Valley Development Association, on November 17, 1900, passed the following resolution as a result of the investigations on the stream:

Whereas the experts of the United States Geological Survey now conducting investigations along Stony Creek report the existence of many excellent storage reservoir sites thereon; and

Whereas the waters of said creek are now used for irrigation, and by the conservation and proper regulation a vast area may be brought to a much higher state of cultivation; and

Whereas the preservation of the forests along the headwaters of said creek is necessary to insure a permanent water supply and also to moderate the flow of flood waters, thereby preventing the rapid filling with silt and detritus of any reservoirs that may hereafter be constructed along said Stony Creek or any of its tributaries: Therefore be it

Resolved, That we, the Sacramento Valley Development Association, earnestly petition the President of the United States to set aside as a forest reserve such of the public lands about the head of said Stony Creek and its tributaries as the experts of the Geological Survey shall recommend as necessary for the protection of the water supply of said creek.

Adopted at a meeting of the Sacramento Valley Development Association held in Oroville, Cal., November 17, 1900.

Practically the same resolutions were also passed by the Water and Forest Association.

In response to the above requests the following area has been temporarily withdrawn from entry, August 14, 1900, pending investigation by the Bureau of Forestry:

Beginning at the northwest corner of T. 23 N., R. 6 W., Mount Diablo meridian; thence south to the northwest corner of T. 20 N., R. 6 W., Mount Diablo meridian; thence west on township line to northwest corner of sec. 2, T. 20 N., R. 7 W.; thence south to southwest corner of sec. 26, township and range aforesaid; thence east to northwest corner of sec. 36, township and range last aforesaid; thence south 1 mile; thence east to northeast corner of T. 19 N., R. 7 W., Mount Diablo meridian; thence south on range line 3 miles to southwest corner of sec. 18, T. 19 N., R. 6 W.; thence east to northeast corner of sec. 19, T. 19 N., R. 6 W. thence south to southeast corner of sec. 31, said township and range aforesaid; thence west to northwest corner of T. 18 N., R. 6 W.; thence south on range line between

s. 6 and 7 W., to southwest corner of sec. 6, T. 17 N., R. 6 W.; ence east to northeast corner of sec. 8, township and range last foresaid; thence south to southeast corner of sec. 32, T. 16 N., R. 6 V.; thence west on township line between Ts. 15 and 16 N., to southest corner of T. 16 N., R. 10 W.; thence north on range line between ts. 10 and 11 W., to northwest corner of T. 23 N., R. 10 W.; thence asterly to northwest corner of T. 23 N., R. 6 W., the place of beginning.

Local stock and lumbermen are now (1903) violently opposing the creation of this and other proposed reserves in the basin of the Sacramento River. It is believed that this is largely done because the true purpose of forestry is not understood.

A forest reserve is created for the permanent benefit and ultimate improvement of the district wherein it exists. These benefits may be divided into two classes: First, forestry; second, irrigation. There are some good timbered lands on the headwaters of Stony Creek and the crest of the range immediately to the west. Under the ordinary methods of procedure a lumber company entering into business in a timbered district will cut off the entire forest cover as rapidly as possible, sell the product, clean up its business, and get out of the country, leaving the district in a denuded and wrecked condition. This is so abundantly evident in so many different localities in California that it is scarcely necessary to enter into an extended argument as to its impropriety. The county is a permanent loser, because when these lands are once cut off they are usually abandoned to the State because of delinquent taxes. There is no permanent employment offered for citizens of the community, and the result is a rapid wrecking of the forest.

The effect on the State of reckless deforestation is the destruction of a permanent source of lumber supply. This method of procedure has led to the marked deterioration of many of the older countries. The policy advocated for the Federal Government is that looking toward a continuous use of the forest as a permanent source of lumber supply along lines of development now practiced by England in India, by France, Germany, Sweden, and other European countries. With this method only the matured or ripened tree is cut off. The younger trees are protected and saved. The policy is distinctly one for the continued utilization of the forest and not for its destruction. Again, by far the greatest enemy of forests is fire, and with the creation of a forest reserve there will be provided guards to prevent these fires and fight them when they are once started. The general effect on the nation and State is to furnish a permanent lumber crop for the development of towns and cities.

The forest is a great natural regulator of the waters used in irrigation. A stream proceeding out of a denuded area becomes a violent torrent immediately following a storm, washing great gullies in the

sides of the hills, carrying down débris and stones, and deposit them on the valleys and lowlands. The stream in the summer time dries up, and a condition of desolation is an almost inevitable result. If storage reservoirs are built upon such a stream the tendency is to rapidly fill them with débris. An engineer could scarcely recommend the construction of a reservoir on any of the branches of Stony Creek if the drainage basin above it were denuded.

Stony Creek presents great natural opportunities for the regulation of storm waters. Surveys made for sites by the Geological Survey show that the construction of reservoirs is commercially feasible. The climatic conditions along the foothills are such as to permit, with irrigation, the raising of any crop that is grown in the State of California. It is believed that the day is not distant when these reservoirs will be built, when the foothill land will be under cultivation, when the products therefrom will be as valuable as from any portion of the State, and when the population on these lands will approach an inhabitant to each 2 acres.

Glenn County is confronted to-day with a decreasing population and a decreasing assessed valuation, as a result of efforts at dry farming. With natural opportunities greater than any that exist in southern California it has not reached 1 per cent of the development which is possible. It is believed that the day will come when this development will occur, and when the conservation of the stream will be the basis of its successful maturing. It would, therefore, seem to be ill-advised for the county to oppose the creation of a forest reserve which looks toward the development of such a condition as that suggested, particularly as the only compensation which would be received therefrom would consist in furnishing pasture for a few thousand sheep and goats, which would range over the hills of the back country.

The forest-reserve policy is not hostile to stockmen. It would oppose such unrestricted overstocking and burning off of mountain sides as is now being practiced in the drainage basin of Stony Creek. In the forest reserves of other portions of the United States where the trees are mature, and where, after careful study, the conclusion has been reached that stock will not injure the reserve, they have been permitted to range therein under proper regulations and restrictions and particularly with safeguards against fires. Cattle range throughout the forest reserves of the Sierra Nevada. In selecting the persons who may range stock in these districts, preference is always given to local residents. It is absurd to claim that this forest reserve is being presented and promoted by large corporate interests for their selfish advantage. On the other hand, it is recommended and indorsed by many of the most intelligent and far-seeing men of California and of the United States.

A. BLACK BUTTE.

B. STONY CREEK GAGING STATION.

PRECIPITATION AND CLIMATE.

Rainfall records in Stony Creek Basin above the proposed points of mpounding the flood waters are very meager and fragmentary.

A record at Fouts Springs, in the watershed of Little Stony Creek, ıas been furnished by John F. Fouts and S. E. Sites for three seasons, ınd partial records for two other years. There is also a short record ıt Little Stony, in the same basin. A rain gage was placed at Julian's 'anch house on main stream, February, 1901, at the time the gaging ıtation was established. These records are the only ones available lirectly in the watersheds tributary to the proposed reservoirs. Recɔrds for several points outside of the basin are given as being typical ɔf the rainfall at the higher elevations of the watershed. These are Bartlett Springs, on the North Fork of Cache Creek, which adjoins the watershed of Little Stony on the south; Camp Wright, which is situated a few miles west of the crest of Stony Creek watershed; and Weaverville, which is several miles north of the basin.

The records of precipitation at Red Bluff, at the head of Sacramento Valley; at Jacinto, which is situated on the Sacramento River 14 miles southeast of Orland; and at Woodlands, have been selected as typical of the rainfall in the valley lands to be irrigated from the stored waters of Stony Creek.

Precipitation, in inches, at Bartlett Springs, Lake County.

[Latitude, 39° 10′; longitude, 122° 45′; elevation, 2,375 feet; authority, J. E. McMahon.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1897	.....	.....	.....	.....	3.50	6.78	5.36	0.75	0	0	0	0	16.39
1897-98	0	1.70	2.31	3.72	1.53	8.36	.19	.63	2.39	1.10	0	0	21.93
1898-99	0	0	1.87	1.23	13.14	0	8.49	.85	2.47	0	0	0	28.05
1899-1900	0	4.79	10.06	7.87	7.51	1.27	6.42	3.23	.88	0	0	0	42.06
1900-1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901-2	1.17	1.80	5.86	4.02	1.71	22.38	5.98	5.20	3.40	0	0	0	51.52
1902-3	0	5.97	11.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Precipitation, in inches, at Fouts Springs, Colusa County.

[Latitude, 39° 20′; longitude, 122° 40′; elevation, 1,650 feet; authority, John F. Fouts and S. E. Sites.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1885-86	(0)	0.20	19.43	4.85	9.29	2.00	1.65	5.01	0.50	T.	0	0	42.93
1886-87	0	.70	.20	2.83	2.00	7.88	2.12	1.66	T.	T.	T.	0	17.39
1887-88	T.	0	1.25	4.35	10.83	.70	5.00	3.34	2.14	0.65	(0)	(0)	28.25
Mean	0	.30	6.96	4.01	7.37	3.53	2.92	3.34	.88	.22	0	0	29.52
1892-93	.....	.....	.....	.....	2.08	7.11	5.17	1.95	.....	.....	.....	.....	[a] 16.31
1900-1901	.....	.....	.....	5.41	12.57	4.06	.....	.79	.....	.....	.....	.....	[a] 22.83

[a] Year incomplete.

Precipitation, in inches, at Little Stony, Colusa County.

[Latitude, 39° 25′; longitude, 122° 30′; authority, C. M. Polley.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1884-85	.....	.....	.....	8.40	1.29	1.04	0	1.38	0	1.19	0	0	[illegible]
1885-86	0	0.27	13.29	3.51	3.44	0	1.10	3.89	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Precipitation, in inches, at Julian's ranch, on Stony Creek, Glenn County.

[Latitude, 39° 35′; longitude, 122° 30′; elevation, 750 feet; authority, Mrs. Lee Julian.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1900-1901	.....	.....	.....	.....	.....	4.26	0.12	1.24	0.50	0	0	0	[illegible]
1901-2	1.07	0.60	3.18	0.82	0.85	9.27	3.24	2.37	2.06	0	0	0	[illegible]

[a] Year incomplete.

Precipitation, in inches, at Camp Wright, Mendocino County.

[Latitude, 39° 45′; longitude, 123°; elevation, 1,800 feet; authority, U. S. War Department.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1864-65	0.03	0.85	6.19	12.20	3.64	4.88	3.57	0.36	0.43	0	0	0	[illegible]
1865-66	.81	.87	16.67	2.05	15.83	4.30	11.80	1.05	.....	.....	.....	.....	[a] [illegible]
1866-67	0	0	5.92	24.67	8.92	7.85	2.38	3.10	.01	0	0	0	[illegible]
1867-68	1.56	3.75	6.38	29.08	8.61	5.89	9.11	3.25	.71	1.58	0	0	[illegible]
1868-69	.05	.25	2.79	6.63	13.57	4.13	3.80	4.51	.55	0	0	0	[illegible]
1869-70	1.42	.84	5.38	8.06	7.03	6.61	2.40	2.02	.39	0	0	0	[illegible]
1870-71	0	0	1.28	1.19	2.66	4.60	7.10	1.07	1.96	0	0	0	[illegible]
1871-72	.50	.31	4.03	16.64	11.52	19.78	5.34	.66	.12	.04	0	0.20	[illegible]
1872-73	0	.36	5.20	7.24	3.55	6.92	2.91	1.13	.04	.30	0.10	0	[illegible]
1873-74	.05	.34	4.98	15.50	12.94	5.46	7.26	3.72	1.16	.26	.01	0	[illegible]
1874-75	0	5.61	12.99	2.27	9.83	1.06	1.76	.59	2.32	0	0	0	[illegible]
Mean	.40	1.20	6.53	11.41	8.92	6.50	5.22	1.95	.77	.20	.01	.02	[illegible]

[a] Year incomplete.

Precipitation, in inches, at Weaverville, Trinity County.

[Latitude, 40° 46′; longitude, 123° 25′; elevation, 2,162 feet; authority, George E. Noonan.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
69–70	1.06	1.03	8.01	6.15	10.11	9.64	2.05	1.06	0.22	0	0	0	39.33
70–71	.64	1.39	6.41	9.43	8.16	11.19	3.02	1.73	1.03	0.14	0	0	43.14
71–72	.29	.40	11.50	3.52	19.62	15.09	3.11	2.43	.84	.17	0	0.25	57.22
72–73	.85	.78	3.01	6.32	6.51	4.29	2.78	.50	.27	0	0	0	24.81
73–74	1.80	4.39	4.02	9.57	15.40	4.41	3.12	3.58	2.67	.70	0	0	49.66
74–75	0	1.57	10.30	1.32	6.59	.46	2.14	.19	1.22	.93	0	0	24.72
75–76	0	2.82	15.39	11.94	9.69	9.49	8.23	2.79	1.63	.15	0.47	0	62.60
76–77	.67	7.38	1.50	.29	6.27	6.24	4.52	2.26	1.62	1.72	.02	0.21	32.70
77–78	0	1.83	8.72	6.50	19.83	16.20	8.53	2.42	1.07	.07	.02	.03	65.22
78–79	1.28	1.80	3.58	4.91	2.02	6.48	12.84	4.05	4.02	.68	.02	.03	41.71
79–80	.03	2.08	8.09	13.20	6.64	2.59	4.72	10.78	1.46	.23	.38	.36	50.56
80–81	0	.55	1.49	14.14	18.61	11.05	1.21	3.13	1.15	.99	0	0	52.32
81–82	.93	3.77	2.58	8.00	4.19	6.90	3.62	2.44	1.29	0	0	0	33.72
82–83	1.38	8.36	.78	5.05	4.46	1.50	3.24	5.00	3.72	0	0	0	33.49
83–84	.88	2.45	1.50	4.97	8.81	3.56	5.10	6.29	1.60	2.93	.13	0	38.22
84–85	.44	.11	16.56	6.78	3.68	3.70	.15	2.78	.51	1.41	0	0	36.12
Mean	.61	2.54	6.47	7.15	9.41	7.05	4.27	3.21	1.52	.63	.07	.05	42.84

Precipitation, in inches, at Jacinto, Glenn County.

[Latitude, 39° 35′; longitude, 122°; elevation, 110 feet.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1892–93	.....	.....	6.32	8.13	4.20	2.99	3.71	0.87	1.44	0	0	0	29.49
1893–94	0.47	0.06	2.67	1.61	4.50	1.47	.89	.51	1.24	0	0	0	13.42
1894–95	1.20	1.33	.35	8.69	8.73	1.86	1.74	2.49	.22	0	.36	0	26.97
1895–96	2.33	0	1.10	.94	9.37	.24	2.92	4.03	.69	0	0	.52	22.14
1896–97	.63	.68	3.06	5.28	3.78	3.54	1.72	.77	.60	.44	0	0	20.50
1897–98	0	2.12	1.16	1.40	.76	3.42	.31	2.07	0	0	0	0	11.24
1898–99	.35	.41	.49	1.39	6.36	0	4.29	.36	1.21	.53	0	0	15.39
1899–1900	0	2.68	4.40	3.40	3.06	.17	1.27	1.68	.72	0	0	0	17.38
1900–1901	0	2.42	5.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	[a] 7.42
Mean	.62	1.21	2.72	3.85	5.09	1.71	2.11	1.59	.76	.12	.04	.06	18.22

[a] Year incomplete.

Precipitation, in inches, at Woodlands, Yolo County.

[Latitude, 38° 42′; longitude, 121° 47′; elevation, 68 feet; authority, O. P. Co., 1878–1899, and Eldrug store, 1894–1899.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot
1878	.....	.....	.....	.....	8.17	8.86	3.88	1.47	0.65	0	0	0	[illegible]
1878-79	0.17	0.22	0.89	0.42	3.08	3.20	4.74	1.91	1.68	0.24	0	0	[illegible]
1879-80	0	.21	2.09	3.69	1.04	1.60	.93	6.96	.35	0	0	0	[illegible]
1880-81	0	0	.06	8.77	4.94	1.86	1.05	1.53	0	.33	0	0	[illegible]
1881-82	0	.37	2.08	2.25	.89	1.88	1.89	1.37	0	0	0	0	[illegible]
1882-83	.59	1.38	2.40	.51	1.98	.45	3.13	1.23	4.12	0	0	0	[illegible]
1883-84	.44	1.03	.29	.29	3.47	3.24	4.69	3.83	0	0	0	0	[illegible]
1884-85	0	1.00	0	4.63	1.43	.12	.10	1.44	0	0	0	0	[illegible]
1885-86	0	.20	8.70	3.75	4.78	0	1.31	4.10	0	0	0	0	[illegible]
1886-87	0	0	0	1.29	.80	5.58	.65	1.53	0	0	0	0	[illegible]
1887-88	0	0	.40	3.30	4.20	1.27	2.38	.10	1.10	0	0	0	[illegible]
1888-89	.56	0	5.57	4.97	0	.55	6.21	.62	1.46	.35	0	0	[illegible]
1889-90	0	5.32	3.75	8.48	5.10	2.40	3.35	1.00	1.60	0	0	0	[illegible]
1890-91	.60	0	0	2.35	.82	8.08	.35	1.17	.43	0	0	0	[illegible]
1891-92	0	0	.40	3.10	2.05	2.73	2.14	1.28	2.22	0	0	0	[illegible]
1892-93	0	.57	5.47	6.10	2.88	2.78	2.00	.62	.61	0	0	0	[illegible]
1893-94	0	.08	1.71	1.92	4.12	2.15	.88	.42	1.49	.77	0	0	[illegible]
1894-95	.85	1.12	.85	10.82	9.83	1.28	.91	.52	.45	0	0	0	[illegible]
1895-96	1.37	.19	1.69	.90	11.87	.11	2.08	6.73	.76	0	0	0.35	[illegible]
1896-97	.50	1.27	3.76	2.03	3.32	5.21	2.75	.25	.29	.09	0	0	[illegible]
1897-98	.02	1.81	.56	.72	.43	3.35	.12	.21	1.38	.18	0	0	[illegible]
1898-99	.35	.98	.47	1.53	5.67	.14	14.46	.13	.08	.78	0	0	[illegible]
1899-1900	0	3.55	3.01	3.53	2.14	.40	1.20	.96	.54	0	0	0	[illegible]
1900-1901	0	1.46	5.17	1.22	3.26	5.39	.51	1.91	.71	0	T.	0	[illegible]
1901-2	0	.90	4.21	.92	.34	6.52	2.01	1.25	.57	.40	0	0	[illegible]
Mean	.23	.90	2.23	2.81	3.46	2.74	2.54	1.70	.82	.13	0	.01	[illegible]

NOTE.—The figures for the years 1894 to 1899, inclusive, are the mean of two records.

Mean monthly and annual temperature, in degrees Fahrenheit, at Fruto, Colusa County.

[Elevation, 295 feet.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Mean annual
1888-89	83.3	70.9	57.4	49.7	47.3	52.0	58.6	64.0	70.3	84.7	84.5	84.5	[illegible]
1889-90	82.9	63.5	58.2	48.9	41.6	48.3	52.9	62.3	71.2	.....	.....	.....	[illegible]

Mean monthly and annual temperature, in degrees Fahrenheit, at Willows, Glenn County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual.
78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54.0	45.5	.....
79	42.9	52.3	56.9	62.5	66.1	82.2	84.1	84.6	77.5	63.1	50.3	43.3	63.8
80	42.7	45.2	48.9	57.4	67.5	77.2	86.4	80.3	75.5	66.6	50.5	50.1	62.2
81	49.2	52.3	55.1	66.1	74.7	[77.4]	86.4	77.2	75.7	58.2	51.4	46.5	[64.2]
82	43.6	41.8	58.6	57.8	72.4	82.7	88.3	84.5	78.2	64.9	58.2	43.9	64.2
83	37.3	46.5	62.0	63.8	70.1	[77.4]	85.8	81.9	81.1	63.8	55.2	45.4	[64.2]
84	47.4	46.0	58.9	53.2	64.7	76.6	78.2	79.6	68.1	62.4	57.2	45.2	61.5
85	45.2	47.2	65.8	65.0	71.6	73.1	79.2	81.9	76.9	69.0	51.0	50.5	64.7
86	44.1	53.1	52.3	55.6	67.5	81.1	82.7	83.1	80.0	64.2	52.9	51.0	64.0
87	50.0	45.7	60.2	64.7	73.1	80.0	86.3	87.0	78.4	71.7	56.0	46.3	66.6
88	40.3	51.1	51.6	64.1	67.2	70.9	79.8	78.8	84.2	67.8	52.5	47.6	63.0
89	42.9	47.6	51.8	59.7	67.9	80.3	82.2	79.7	74.7	60.7	53.0	46.6	62.3
90	42.2	47.4	49.9	57.7	69.3	69.6	.....	.....	.....	.....	.....	.....	.....
Mean	44.0	48.0	55.6	60.6	69.3	77.4	83.6	81.7	77.3	64.8	53.5	46.8	63.6

Mean monthly and annual temperature, in degrees Fahrenheit, at Woodlands, Yolo County.

[Elevation, 63 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual.
1876	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	53.9	46.6	.....
1877	49.7	54.6	60.9	61.7	65.7	77.1	80.1	76.1	74.7	59.9	54.9	48.6	63.7
1878	48.7	50.7	56.4	61.6	67.4	75.4	76.0	75.7	68.4	63.2	54.5	45.3	61.9
1879	44.4	54.3	57.7	61.7	64.3	76.0	78.4	79.6	74.6	64.6	53.3	45.0	62.8
1880	44.9	47.2	50.0	56.3	65.2	73.8	78.7	76.2	72.9	65.9	52.7	51.6	61.2
1881	50.4	55.3	53.4	64.1	70.8	75.0	88.8	77.0	74.3	64.1	51.0	49.2	64.4
1882	46.1	45.4	52.7	61.0	72.3	74.7	79.9	76.4	72.5	60.8	50.9	48.9	61.8
1883	42.3	47.0	56.4	58.1	65.9	79.4	78.8	75.5	75.5	63.2	54.7	42.0	61.6
1884	46.5	45.6	54.2	56.1	66.5	69.3	79.2	80.1	72.1	68.6	59.0	51.1	62.4
1885	47.7	55.4	63.6	65.5	72.9	68.5	74.7	77.5	73.8	67.6	[55.2]	53.0	[64.6]
1886	48.1	55.3	57.1	61.5	70.8	78.4	80.2	78.6	71.7	55.5	53.3	51.1	63.5
1887	49.2	47.6	60.8	62.0	70.0	81.6	82.8	78.6	77.1	78.1	68.1	51.9	67.3
1888	43.2	46.1	48.1	51.7	62.5	67.3	73.4	76.1	74.6	68.8	58.3	50.1	60.0
1889	44.0	46.5	54.0	59.9	65.9	72.1	75.8	71.8	70.9	58.9	53.3	49.0	60.2
1890	41.2	45.6	50.9	59.4	63.8	70.7	.....	.....	.....	.....	.....	.....	.....
Mean	46.2	49.8	55.4	60.0	67.4	74.2	79.0	76.9	73.3	64.6	55.2	48.8	62.6

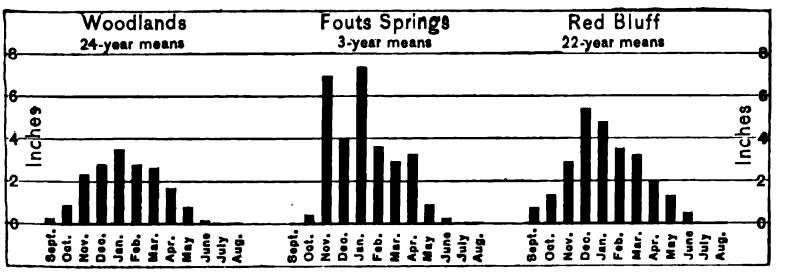


FIG. 1.—Mean monthly precipitation at Woodlands, Fouts Springs, and Red Bluff.

Climatological data for Corning, Orland, and Willows, three po within or close to the land that would be irrigated from the wa stored in the Stony Creek Basin, are given for the years 1897 to 1 inclusive:

Climatological data for Corning, Orland, and Willows.

Stations.	Counties.	Elevation.	Year.	Temperature (degrees Fahrenheit).					Precipitation (inches).					Sky.		
				Annual mean.	Highest.		Lowest.		Total for year.	Greatest monthly.	Month.	Total snowfall.	Rainy days.	Clear days.	Partly cloudy days.	Cloudy days.
					Degrees.	Date.	Degrees.	Date.								
Corning	Tehama	277	1897	61.2	110	Aug. 19	27	Dec. 22	16.54	5.69	Feb.	0	...	...	...	...
			1898	59.7	112	June 25	23	Dec. 11	.....	....	.....	5	...	260	0	105
			1899	62.2	110	July 18	25	Feb. 4	27.72	8.13	Jan.	0	44	228	0	137
			1900	63.1	110	July 19	32	Dec. 31	21.55	4.61	Jan.	0	51	213	8	144
			1901	63.8	108	June 28	26	Jan. 1	20.66	6.09	Jan.	3.5	41	227	0	138
Orland	Glenn	254	1897	64.9	110	Aug. 19	27	Dec. 22	14.14	4.01	Feb.	0	...	...	...	...
			1898	65.6	118	Aug. 12	26	Jan. 12	7.93	3.64	Feb.	0	25	229	4	132
			1899	64.4	115	July 19	26	Feb. 4	22.41	6.98	Jan.	0	65	195	3	167
			1900	62.0	112	...do....	29	Dec. 31	18.40	4.61	Nov.	0	60	200	1	164
			1901	65.0	116	Aug. 3	24	Jan. 1	17.86	5.14	Feb.	1	40	...	...	...
Willows	...do	132	1897	....	105	June 30	32	Dec. 20	10.85	4.26	Feb.	0	...	...	...	...
			1898	64.8	112	Aug. 12	30	Dec. 30	6.94	2.46	Feb.	0	20	273	4	88
			1899	63.0	115	July 24	32	Feb. 2	19.15	6.56	Jan.	0	46	250	0	115
			1900	66.3	105	July 7	35	Dec. 31	14.28	4.37	Nov.	0	42	283	9	123
			1901	67.2	109	Aug. 3	30	Jan. 1	16.54	3.88	Feb.	0	39	255	0	110

On page 4 of the California section of the Climate and Crop Bulletin of the Weather Bureau for November, 1900, is an excellent and more complete collection of data, compiled by Maurice Connell, observer, which are given in full as fairly representing the climatic conditions of the territory on the west side of the Sacramento Valley in the vicinity of Willows, Orland, and Corning.

Red Bluff is the county seat of Tehama County, at the northern end of the Sacramento Valley. The city is situated on the western bank of the Sacramento River, in latitude 40° 10′ north, longitude 122° 14′ west, the average elevation above sea level being 309 feet. The land slopes gently to the river, and within a radius of 5 miles the country is comparatively flat. The general movement of the air is from the north and northeast into the valley from the mountains on the north and east. During the summer months, however, there is a well-marked northerly movement of the air, which is in part due to the strong westerly indraft through the Golden Gate and its subsequent deflection northward through the valley. The highest temperature recorded is 114° and the lowest 18°. The average annual precipitation is 25.56 inches.

onthly and annual mean temperature at Red Bluff, Cal., in degrees Fahrenheit, with departures from normal.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Departure from normal.
8	47.3	50.2	55.5	60.4	67.4	81.0	81.6	83.2	72.9	65.4	55.6	47.4	64.0	+1.6
9	44.6	53.6	57.0	61.3	62.5	78.7	81.6	83.4	77.2	64.0	51.0	44.6	63.3	+ .9
0	44.5	46.5	49.7	55.8	64.1	73.9	83.4	77.4	74.7	65.3	50.0	49.4	61.2	−1.2
1	50.0	53.0	55.6	63.6	69.3	72.8	78.7	76.4	71.5	57.5	51.0	45.9	62.1	− .3
2	44.1	44.4	52.5	56.6	67.4	75.6	84.3	81.2	60.8	58.3	51.3	47.5	60.2	−2.2
3	41.2	45.1	58.3	56.3	64.3	80.3	84.9	79.9	75.4	57.7	50.6	44.4	61.5	− .9
4	46.2	45.9	51.6	56.8	68.0	69.6	78.4	81.5	67.3	62.1	54.7	47.5	60.8	−1.6
5	47.5	53.5	61.0	62.1	70.4	71.6	80.7	83.8	74.8	65.6	52.7	49.3	64.4	+2.0
6	46.2	54.5	52.8	57.7	66.9	79.1	82.6	81.5	75.6	60.7	51.3	50.0	63.2	+ .8
87	48.7	43.4	58.9	60.2	68.8	77.1	85.9	81.3	76.4	71.1	55.2	48.2	64.4	+2.0
88	40.9	53.9	54.5	67.0	68.1	70.7	80.9	83.7	81.2	68.2	54.8	48.3	64.5	+2.1
89	45.8	51.6	56.8	61.0	66.8	80.0	81.3	80.0	76.0	61.4	54.4	44.8	63.8	+ .9
90	39.2	45.2	50.8	60.3	67.6	72.6	80.4	79.5	74.4	65.0	57.9	45.0	61.5	− .9
91	48.5	44.4	55.0	57.8	66.8	72.2	82.6	83.1	72.9	66.0	56.8	42.5	62.4	0.
92	47.1	53.0	56.0	54.1	65.6	71.8	78.7	80.4	72.0	63.5	56.1	47.6	62.2	− .2
93	43.2	46.8	49.8	54.6	65.8	73.4	80.4	81.0	67.5	61.4	53.5	50.2	60.6	−1.8
94	42.4	45.3	51.5	61.4	66.8	69.1	83.0	82.0	74.8	63.9	59.0	45.0	62.0	- 4
95	43.8	52.8	52.8	59.1	66.2	78.2	80.0	81.2	68.5	67.0	53.6	43.4	62.2	− .2
96	48.8	53.2	53.8	52.2	61.0	77.4	85.3	78.8	72.8	67.2	50.8	49.0	62.5	+ .1
97	45.8	47.0	54.4	63.2	72.6	74.0	82.1	80.2	72.6	62.9	49.7	46.0	62.0	− .4
98	42.4	51.0	59.2	64.4	63.6	75.4	83.1	81.3	72.6	64.3	53.6	45.7	62.5	+ .1
99	48.8	51.6	52.2	60.8	63.2	77.9	82.0	73.8	78.0	61.0	54.4	45.5	62.4	0.
Means (22 years)	45.2	49.3	54.6	59.3	66.6	75.0	81.9	81.1	72.9	63.7	53.5	46.7	62.4	

Temperature summaries, Red Bluff, Cal.

Month.	Highest monthly mean.		Lowest monthly mean.		Absolute maximum.			Absolute minimum.			Mean daily range.	Mean daily variability of mean temperature.	Mean relative humidity.	
	Year.	° F.	Year.	° F.	Day.	Year.	° F.	Day.	Year.	° F.			5 a.m.	5 p.m.
													P. ct.	*P. ct.*
January	1881	50.0	1890	39.2	27	1899	77	14	1888	18	15.6	3.6	87	68
February	1886	54.5	1887	43.4	25	1888	82	14	1884	22	18.9	3.1	82	56
March	1885	61.0	1880	49.7	9	1892	86	16	1880	28	19.2	3.0	82	53
April	1888	67.0	1892	54.1	24	1898	96	18	1885	34	22.2	3.3	76	43
May	1897	72.6	1896	61.0	29	1887	110	11	1892	38	24.1	3.9	71	38
June	1878	81.0	1884	69.6	30	1891	110	1	1898	44	27.1	3.5	59	26
July	1887	85.9	1884	78.4	8	1887	112	1	1881	53	30.5	3.2	49	18
August	1885	83.8	1889	73.8	22	1891	114	22	1881	52	30.6	3.0	49	20
September	1888	81.2	1882	60.3	1	1891	107	9	1884	46	26.7	3.2	57	28
October	1887	71.1	1881	57.5	5	1892	97	14	1881	32	24.6	3.3	67	38
November	1894	59.0	1897	49.7	3	1890	88	30	1880	26	21.4	3.5	75	55
December	1893	50.2	1891	42.5	5	1885	79	13	1884	25	13.4	3.5	87	70
Annual	.....	85.9	.....	39.2	.....	.....	114	.....	.....	18	22.8	3.3	70	43

Precipitation exceeding 2.50 inches in any consecutive twenty-four hours.

January 16, 1878
December 5, 1879
January 29, 1881
December 14, 1881
November 3, 1882
November 10, 1885
December 15, 1896
January 10, 1899

Monthly and annual precipitation, in inches, at Red Bluff, Cal., with departures from normal.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1878	20.71	16.66	4.16	2.26	0.89	0	0	0	0.42	1.56	1.66	0.69	49.01
1879	3.18	3.67	5.39	2.12	2.18	.30	.04	.28	T.	.48	6.05	9.95	33.64
1880	2.01	1.66	1.70	7.05	1.04	0	0	0	0	.08	.14	12.85	26.53
1881	9.40	2.79	.51	1.83	.79	.51	T.	0	1.07	1.61	.73	5.69	24.93
1882	2.81	3.94	2.67	2.12	.33	.15	0	0	.49	2.80	5.07	1.44	21.82
1883	.87	.39	2.60	1.96	2.96	T.	0	T.	1.04	2.68	.74	.52	13.76
1884	3.55	2.21	7.81	4.31	.18	.97	0	T.	.36	.90	.04	7.73	28.05
1885	1.84	1.19	T.	.62	.64	1.37	.05	0	2.91	.10	17.05	3.86	29.63
1886	4.85	.18	1.31	4.12	.73	T.	T.	T.	0	1.76	.34	3.92	17.21
1887	.57	5.21	1.13	1.76	.77	.26	T.	T.	.06	0	1.52	2.32	13.60
1888	4.08	2.17	3.47	.53	.51	2.61	.07	0	.33	T.	4.32	6.85	24.94
1889	.51	.71	6.83	1.11	2.04	.64	0	0	0	8.41	3.37	9.25	32.87
1890	6.55	3.67	6.14	1.70	2.67	.11	0	0	1.55	.01	0	3.20	25.60
1891	1.36	10.68	1.42	2.27	1.50	.55	.17	0	.19	.64	.46	3.80	23.04
1892	4.30	3.11	2.69	2.92	3.02	.27	T.	T.	.29	1.42	7.25	8.21	33.48
1893	3.82	3.22	6.08	1.42	.61	0	.03	0	1.23	1.09	4.22	2.64	24.36
1894	5.29	2.30	2.40	.55	1.46	1.00	.02	T.	1.11	.89	.95	11.01	26.98
1895	8.29	2.86	2.59	.34	1.65	0	.16	0	1.76	T.	1.93	2.99	22.57
1896	7.30	.27	3.06	3.67	2.42	T.	0	.54	.63	.66	3.41	6.20	28.46
1897	3.22	6.26	1.99	1.22	.06	1.25	0	T.	.03	2.70	1.49	1.86	20.08
1898	.59	5.45	.01	.63	2.28	.14	0	T.	.45	.46	1.21	1.69	12.91
1899	9.29	.01	6.22	.72	.69	.94	0	.02	0	3.02	4.08	3.08	28.07
Average (22 yrs.)	4.74	3.57	3.19	2.06	1.34	.50	.02	.04	.63	1.30	2.95	5.40	25.56

Greatest amount of precipitation, in inches, in twenty-four hours.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	The year.
8	5.11	2.41	0.96	0.76	0.40	0	0	0	0.22	1.38	1.20	0.45	5.11
9	1.54	1.36	1.55	.43	.58	.30	.03	.28	0	.23	1.68	5.04	5.04
0	.94	.41	.78	2.03	.50	0	0	0	0	.08	.10	1.84	2.03
1	3.25	.45	.27	.56	.70	.44	0	0	.74	.68	.33	2.89	3.25
2	.91	1.38	.99	1.03	.26	.13	0	0	.37	1.05	2.88	.62	2.88
3	.76	.39	1.14	1.72	1.10	0	0	0	1.04	1.03	.43	.40	1.72
4	1.12	1.06	2.17	1.47	.14	.56	0	T.	.17	.68	.04	2.00	2.17
5	.63	.45	T.	.22	.58	.71	.05	0	2.91	.06	4.73	1.83	4.73
6	1.89	.18	.43	1.01	.22	T.	T.	T.	0	1.35	.21	1.81	1.89
7	.30	1.59	.62	.82	.39	.14	T.	T.	.06	0	.77	.83	1.59
8	.66	.96	1,25	.53	.15	.84	.04	T.	.33	T.	1.61	1.43	1.61
9	.16	.45	1.95	.31	.85	.58	0	0	0	1.70	1.70	1.83	1.95
90	2.02	1.16	1.71	1.51	1.67	.06	0	0	1.40	.01	0	1.48	2.02
91	.92	3.80	.56	.82	.48	.32	.16	0	.10	.44	.19	.81	3.80
92	1.44	1.36	.91	1.12	1.56	.22	T.	T.	.29	.72	2.30	1.79	2.30
93	1.89	1.40	1.20	.65	.26	0	.03	0	.81	.96	1.85	.85	1.89
94	2.00	.86	.85	.41	.55	.45	.02	T.	1.11	.38	.91	1.70	2.00
95	2.36	1.70	1.05	.16	1.06	T.	.10	T.	.96	T.	.75	1.26	2.36
96	1.38	.17	.58	1.80	.77	T.	0	.54	.58	.61	1.36	2.64	2.64
97	1.04	1.12	.90	.83	.04	.70	0	T.	.02	1.08	1.00	.93	1.04
98	.25	1.54	.01	.41	1.09	.12	0	T.	.20	.23	.58	.92	1.54
99	4.04	.01	1.56	.48	.34	.79	0	.02	0	1.02	1.00	1.54	4.04
Greatest monthly	5.11	3.80	2.17	2.03	1.67	.84	.10	.54	2.91	1.70	4.73	5.04	

Summary of weather conditions at Red Bluff, Cal.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Average number of—													
Clear days	11	12	13	13	17	23	28	28	24	21	17	11	218
Partly cloudy days	10	9	10	11	9	6	3	2	5	7	7	9	88
Cloudy days	10	7	8	6	5	1	0	1	1	3	6	11	59
Rainy days	11	9	11	8	6	4	1	0	3	4	6	12	75
Mean cloudiness	5	4.4	4.6	4.1	3.5	2.1	0.5	0.9	1.7	2.6	4	5.5	3.3

Number of thunderstorms, Red Bluff, Cal.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1884					2		1	1	2	1			
1885		1		1	1	1	2		1				
1886		1			1					1			
1887				1	1		1					2	
1888	1				2	2		1	4				
1889			2	1	2								
1890					1	2		1					
1891			1		1								
1892			1	1		2	1				1	1	
1893				1			1		1				
1894					2	1							
1895		1	1										
1896			2	1	2								
1897						2				1			
1898		2			1	2			1				
1899			1							1			
1900		2	1			1		1	1				

Dates of first and last killing frosts from 1882 to 1899, inclusive.

Year.	Last in spring.	First in autumn.	Year.	Last in spring.	First in autumn.
1882	Mar. 20	Nov. 12	1891	Feb. 25	Dec. [illegible]
1883	Feb. 17	Nov. 25	1892	Feb. 9	Nov. [illegible]
1884	Mar. 11	Dec. 11	1893	Mar. 13	Nov. [illegible]
1885	Feb. 9	Dec. 21	1894	Mar. 4	Nov. [illegible]
1886	Mar. 1	Nov. 21	1895	Mar. 14	Nov. [illegible]
1887	Feb. 27	Nov. 24	1896	Apr. 19	Nov. [illegible]
1888	Mar. 3	Dec. 6	1897	Mar. 30	Nov. [illegible]
1889	Feb. 17	Dec. 27	1898	Mar. 24	Nov. [illegible]
1890	Feb. 27	Dec. 10	1899	Feb. 7	Dec. [illegible]

RUN-OFF.

A gaging station was established January 30, 1901, on Stony Creek at Julian's ranch, 6 miles northwest of Fruto and 1¾ miles above the proposed Mill Site dam. Daily gage heights have been kept and numerous meter measurements have been made, from which rating curves have been constructed for estimating the daily flow and total annual run-off from the basin. The total run-off from February 1 to

ecember 31, 1901, was estimated as 298,578 acre-feet or 0.57 second-et per square mile, which amounts to 7.39 inches in depth over the ntire watershed when taken as 760 square miles.

Table of daily flow from February 1, 1901, to December 31, 1902, given on page 35; also the estimated monthly discharge for 1901 nd 1902.

aily mean discharge in second-feet of Stony Creek at Julian's ranch for 1901.

[Drainage area, 760 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	.....	1,225	2,215	435	555	195	2	10	5	300	47	340
2	.....	1,125	1,785	435	555	195	2	10	5	260	35	1,325
3	.....	1,025	1,540	490	490	165	2	10	5	260	35	630
4	.....	1,025	1,325	490	490	165	2	10	5	225	35	3,875
5	.....	1,225	1,225	435	490	165	.....	5	5	225	35	1,325
6	.....	1,025	1,125	490	435	140	.....	5	5	225	35	1,125
7	.....	925	1,025	435	385	140	.....	5	5	195	35	435
8	.....	925	925	435	385	117	.....	5	5	165	35	435
9	.....	825	925	385	385	97	.....	5	5	140	35	385
0	.....	825	1,025	340	340	97	.....	5	5	140	47	340
1	.....	725	1,125	340	340	77	.....	5	5	117	47	340
2	.....	725	1,025	300	340	62	.....	5	5	97	47	260
3	.....	1,125	925	300	340	62	.....	5	5	77	47	225
4	.....	1,920	825	340	340	47	15	5	5	77	47	195
15	.....	1,325	825	385	340	47	15	5	10	62	77	165
16	.....	3,875	825	385	300	35	15	5	10	47	97	165
17	.....	2,790	825	340	300	35	15	5	10	35	62	140
18	.....	2,215	825	340	300	25	15	2	10	25	77	140
19	.....	10,385	725	300	260	25	15	2	10	15	77	140
20	.....	8,215	630	300	260	15	15	2	10	15	165	117
21	.....	5,611	630	300	300	15	15	2	10	10	165	117
22	.....	3,875	630	260	300	15	10	2	15	5	340	97
23	.....	6,479	555	260	300	10	10	2	15	5	340	77
24	.....	4,526	555	225	300	10	10	2	15	2	300	77
25	.....	3,441	555	225	340	10	10	2	25	.....	225	97
26	.....	3,224	555	225	300	5	10	2	25	.....	195	97
27	.....	2,790	555	225	300	5	10	2	25	260	195	117
28	.....	2,390	555	225	300	5	10	2	25	300	195	117
29	.....	.....	490	630	260	5	10	2	25	340	1,125	97
30	1,325	.....	490	555	260	5	10	2	725	340	630	97
31	1,325	.....	435	.....	225	.....	10	2	.....	62	.....	97

Daily discharge, in second-feet, of Stony Creek at Julian's ranch, for 19[illegible]

[Drainage area, 760 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	[illegible]
1	125	109	5,890	920	690	370	9	2	5	55	10	[illegible]
2	150	125	7,000	1,000	620	320	9	2	5	55	10	[illegible]
3	125	125	4,360	1,080	550	270	9	2	5	55	10	[illegible]
4	125	109	3,750	1,165	550	270	9	2	5	55	10	[illegible]
5	125	125	2,900	1,250	490	270	9	2	5	55	10	[illegible]
6	109	430	3,315	2,510	490	225	5	2	5	55	15	[illegible]
7	109	2,390	3,315	4,680	840	225	2	2	5	55	15	[illegible]
8	109	3,175	5,170	3,815	1,000	225	2	2	5	67	40	[illegible]
9	109	3,175	4,520	2,900	920	185	2	2	5	67	5.06	[illegible]
10	109	3,750	3,175	2,510	840	185	2	2	9	67	3.06	[illegible]
11	109	5,170	2,900	2,275	765	150	2	2	9	67	2.10	[illegible]
12	109	3,175	2,510	1,940	840	150	2	2	9	67	1.55	[illegible]
13	109	2,510	2,510	1,430	840	150	2	2	9	67	1.43	[illegible]
14	109	2,765	2,510	1,525	840	125	2	2	9	80	1.34	[illegible]
15	109	4,360	2,510	1,525	690	125	2	2	9	80	1.34	[illegible]
16	109	3,175	2,510	1,430	620	109	2	2	9	80	1.34	[illegible]
17	109	3,035	2,390	1,340	620	94	2	2	9	80	1.43	[illegible]
18	109	2,160	2,275	1,250	620	94	2	2	9	80	2.76	[illegible]
19	109	2,160	2,050	1,165	550	80	2	2	9	80	3.06	[illegible]
20	109	2,390	2,050	1,080	490	67	2	2	9	80	2.65	[illegible]
21	109	3,315	1,940	1,165	490	55	2	2	9	80	2.10	[illegible]
22	125	4,360	1,940	1,000	430	44	2	2	9	94	2.06	[illegible]
23	125	7,600	1,080	1,080	430	44	2	2	9	94	1.94	[illegible]
24	125	14,650	1,080	1,000	370	35	2	2	14	185	1.94	[illegible]
25	109	13,150	1,000	1,080	370	35	2	2	14	225	1.85	[illegible]
26	109	9,890	1,000	920	370	27	2	5	14	185	1.85	[illegible]
27	109	12,660	920	840	320	5	2	5	14	150	1.70	[illegible]
28	109	7,600	920	840	320	5	2	5	14	125	1.65	[illegible]
29	109	.....	920	765	270	5	2	5	14	125	1.35	[illegible]
30	109	.....	920	690	320	5	2	5	14	125	1.43	[illegible]
31	109	.....	920	.....	370	.....	2	5	.....	109	.....	[illegible]
Total	3,532	117,638	80,220	45,670	17,925	3,949	100	80	269	2,844	47,535	[illegible]
Mean	114	4,201	2,588	1,522	578	132	3	3	9	92	1.584	[illegible]
Run-off, per square mile	.15	5.53	3.41	2.00	.76	.17	0	0	.01	.12	2.08	[illegible]
Run-off, in inches	.17	5.76	3.93	2.23	.88	.19	0	0	.01	.14	2.32	[illegible]

Estimated monthly discharge of Stony Creek at Julian's ranch.

[Drainage area, 760 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1901.						
February [a]	10,385	725	2,707	150,339	3.56	3.71
March	2,215	435	893	54,908	1.18	1.36
April	630	225	361	21,481	.48	.54
May	555	225	349	21,459	.46	.53
June	195	5	66	3,927	.09	.10
July	10	0	7	430	.01	.01
August	10	2	4	246	.01	.01
September	725	5	35	2,083	.05	.06
October	340	0	130	7,993	.17	.20
November	1,125	35	161	9,580	.21	.23
December	3,875	77	425	26,132	.56	.64
11 months	10,385	0	428	298,578	.57	7.39
1902.						
January	150	109	114	7,010	.15	.17
February	14,650	109	4,201	233,312	5.53	5.76
March	7,000	920	2,588	159,130	3.41	3.93
April	4,680	690	1,522	90,565	2.00	2.23
May	1,000	270	578	35,540	.76	.88
June	370	5	132	7,855	.17	.19
July	9	2	3	184	0	0
August	5	2	3	184	0	0
September	14	5	9	536	.01	.01
October	225	55	92	5,657	.12	.14
November	5,005	109	1,584	94,255	2.08	2.32
December	2,765	690	1,132	69,604	1.49	1.72
The year	14,650	2	997	703,832	1.31	17.35

[a] Maximum flood discharge of Stony Creek February 19, 1901, 8 p. m., estimated, 18,000 second-feet.

SILT.

The vegetable covering, geologic character, and grades of the watershed of Stony Creek and tributaries are such that the streams, even in flood, carry a comparatively small quantity of silt.

The setting aside of the principal part of the watershed as a forest reserve would assure the preservation of the forest at the headwaters and the regulation of the run-off, and hence the continuation of the

present favorable condition for the long life of storage reservoirs that may be built to impound the flood waters of these streams.

STORAGE POSSIBILITIES.

For the investigation of the storage possibilities of Stony Creek nearly the entire drainage basin was visited. Stony Creek has a very peculiar topographic catchment area. The main stream, flowing northerly and parallel with the Coast Range, lies wholly in the sedimentary rock, and is fed by several tributaries coming into it from the west from the granitic crest of the range. These tributaries, until they enter the sedimentary rock, have a very heavy grade, and reservoir sites are therefore not found thereon. At various points in the basin a conglomerate of more or less hardness is upturned in lines parallel with the axis of the main range, and has resisted erosion to a very large extent. Wherever this ridge has been crosscut by the various streams, dam and reservoir sites of more or less merit are found.

No exploration for bed rock was made at any of the following dam sites, and consequently the estimates in this particular are merely preliminary and should be confirmed before construction is undertaken.

GRINDSTONE CREEK.

Grindstone Creek joins Stony Creek in sec. 15, T. 21 N., R. 6 W., Mount Diablo meridian, draining a large part of the most productive portion of the basin. At a point about 4 miles above its mouth the stream intersects and passes through one of the conglomerate ridges above referred to, but as its canyon above is narrow it was not considered of enough importance to make surveys to determine the reservoir capacity of this site.

SALT CREEK.

On Salt Creek the same conglomerate is upturned, and the reservoir conditions are practically the same, except that the water supply is much less.

NORTH FORK OF STONY CREEK.

On the North Fork of Stony Creek, at the town of Newville, a reservoir site was found and surveyed by means of a plane table up to the 60-foot contour. The capacity was found to be 25,400 acre-feet at that level, distributed over an area of 1,350 acres. The foundations and abutments for this dam are not good, however, and the land to be covered would be some of the most valuable in the county. The drainage area tributary to this reservoir site is insufficient to supply this amount of water except in years of excessive rainfall, therefore no estimates of cost of building a dam at this point were made. Owing to this insufficient drainage area, a reconnaissance by means of hand level and barometer was made to determine the possibility of diverting Thomas Creek, the next creek to the west, into this reservoir site. From the cursory examination made it appears that

here are no engineering difficulties to be encountered which could not be overcome, except that of a heavy cost for the work. It would probably not be public policy, however, to divert this stream, as a reservoir site exists, and was surveyed by others several years ago, about 3 miles south of the town of Paskenta, Tehama County, on Thomas Creek. No information as to the capacity or cost of this reservoir could be obtained, and surveys were not considered justified. The dam site appears fair, and the basin above it is extensive. As this was outside of the Stony Creek investigation no surveys were made. The locality upon which this water should logically be diverted is the land naturally tributary thereto, either in the basin of Thomas Creek or at the point where it debouches into the Sacramento Valley.

BRISCOE CREEK.

This creek has a catchment area of 50 square miles of good mountain drainage. The crest of the drainage is a high mountain, locally

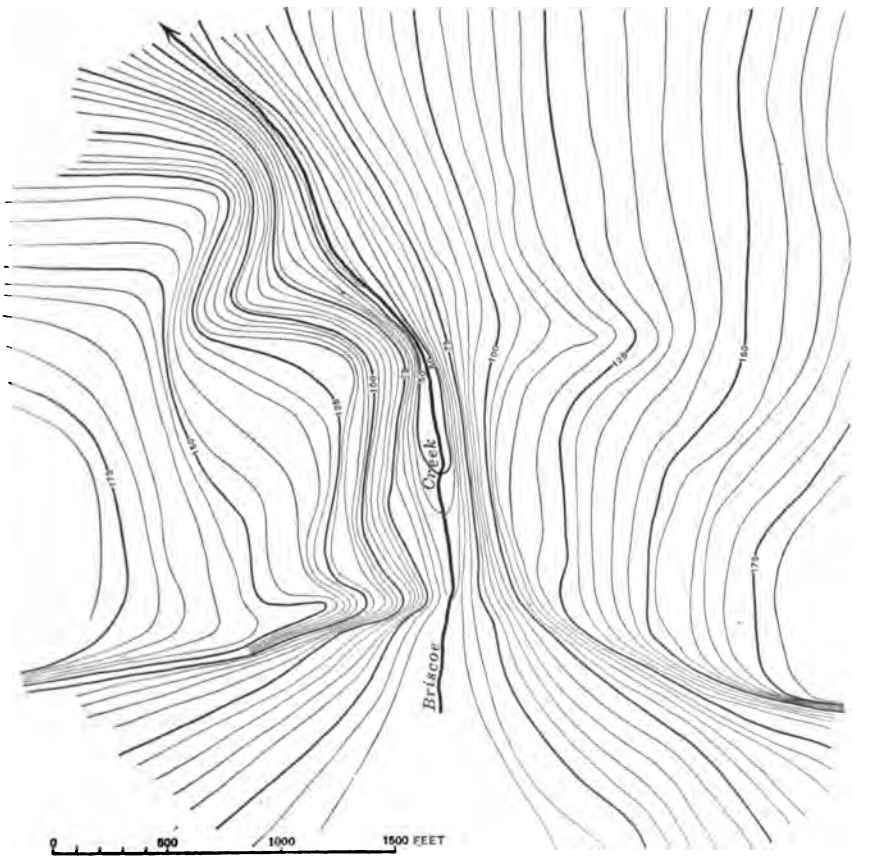


FIG. 2.—Briscoe dam site, Stony Creek.

known as Sheetiron Mountain, and inhabitants of this locality report that it lies in what may be termed a "rainy belt," having a width of

about 6 miles and extending northeast from this mountain abo miles. Briscoe Creek, in sec. 30, T. 20 N., R. 6 W., M. D.M., intersec conglomerate bed in a narrow rocky gorge that in places is only 3

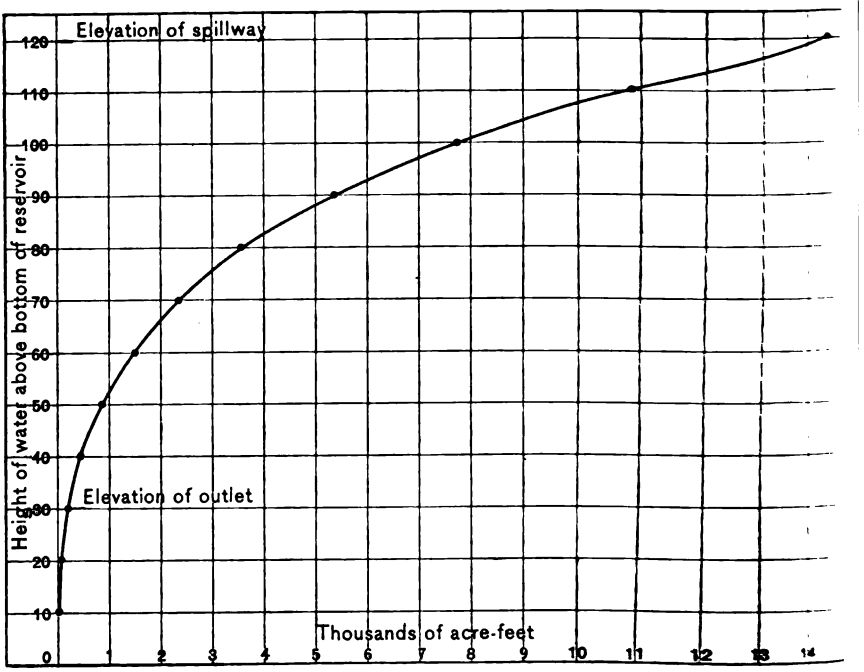


FIG. 3.—Capacity curve, Briscoe reservoir.

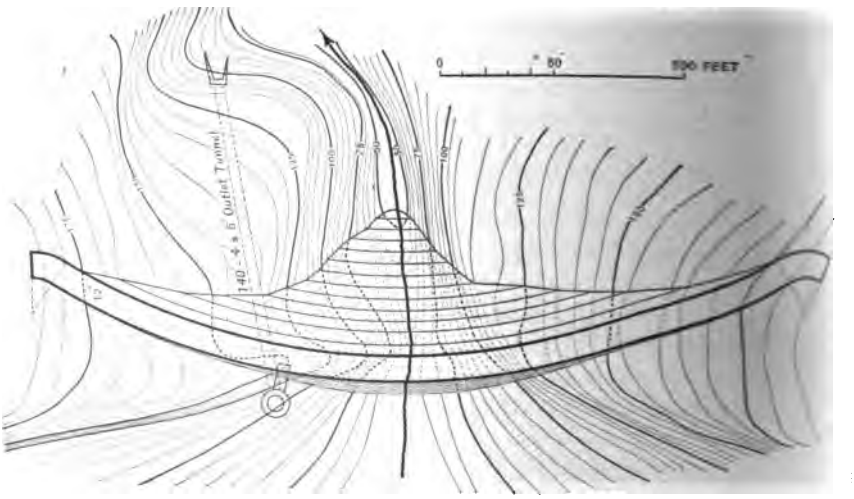
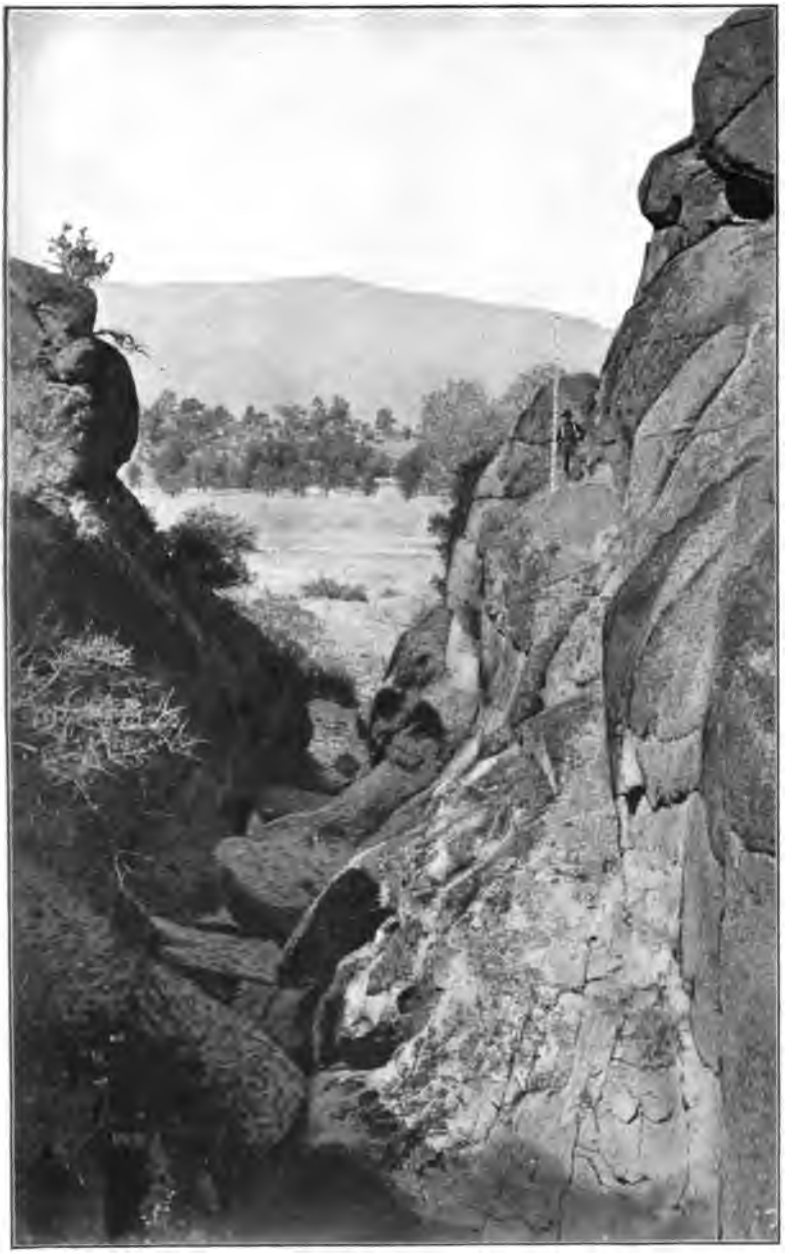


FIG. 4.—Plan of concrete dam, Briscoe reservoir.

wide. The site was surveyed and found to have a capacity of 14,3 acre-feet with a dam 125 feet high. A subsidiary dam at the divide 1,700 feet north of dam site, will also be necessary, with a maximum



BRISCOE CREEK DAM SITE.

eight of 30 feet. The conglomerate at the dam site is very hard and ompact, a sample taken weighing 143 pounds per cubic foot. Bed ock is at the surface in the canyon at the dam site, and the walls of he canyon are good.

It is considered that the best type of dam for this place will be a ock and concrete gravity dam with a concrete spillway at the subidiary dam.

The following estimates with regard to the concrete are based on he assumption that 25 per cent of the conglomerate rock will quarry

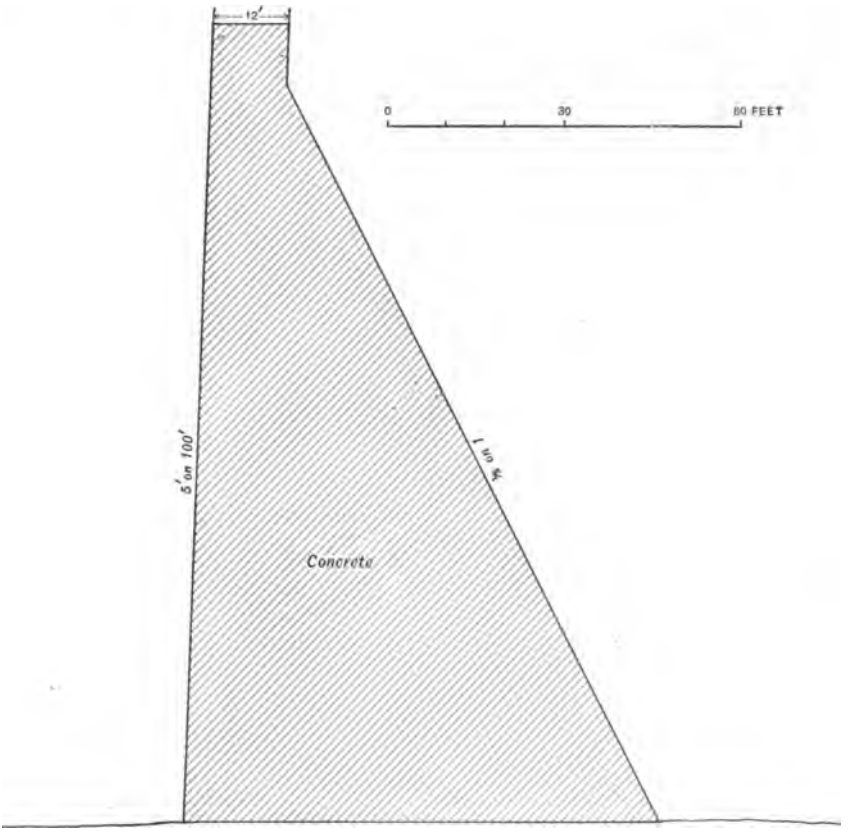


FIG. 5.—Section of concrete dam, Briscoe reservoir.

out in large blocks and that these, after having their surfaces thoroughly cleaned, can be embedded in concrete and will occupy at least one-fifth of the cubic contents of the dam. For purposes of comparison of cost, three types of dam have been estimated upon. First, the above-mentioned concrete gravity dam of light cross section and having a curve upstream on a radius of 300 feet, with a small return curve at each end, to fit the ground. With this design the overflow would be through the spillway. Second, a concrete overflow dam curved with a 300-foot radius and with a cross section the same as

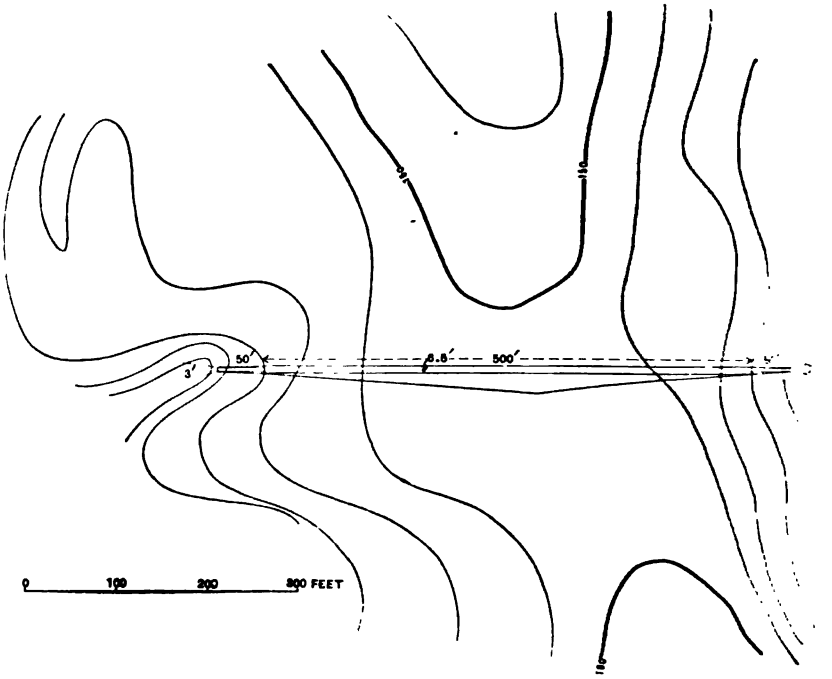


FIG. 6.—Plan of spillway, Briscoe reservoir.

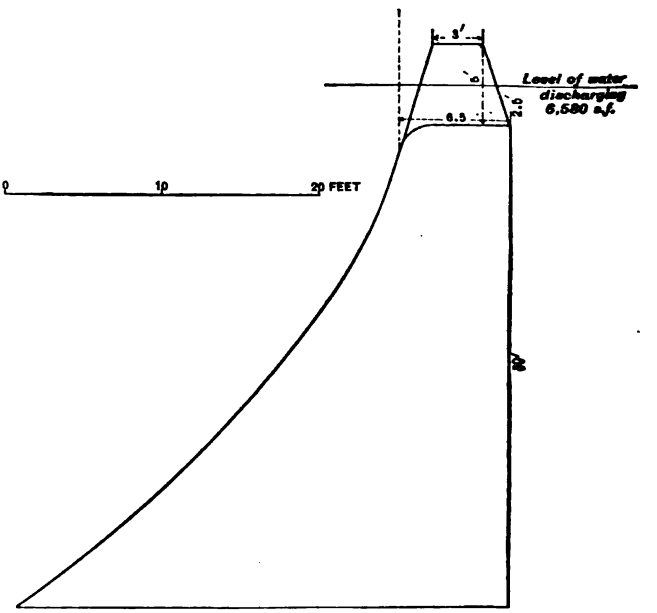


FIG. 7.—Section of spillway, Briscoe reservoir.

BRISCOE CREEK RESERVOIR SITE.

esigned for the San Carlos dam on the Gila River, Arizona. In this lan the surplus water would pass over the dam. And third, a dry ıbble or loose rock dam with straight crest and a plank water face.

In connection with the first and third type a concrete weir dam has een designed for a spillway at the location for the subsidiary dam.

For the second type, or overflow dam, an earth subsidiary dam is esigned with concrete cut-off wall riprapped on water face. A conrete tower and tunnel outlet has been designed for each of the types; hat for the loose rock type requiring a longer outlet tunnel and ›nger bridge, connecting tower with crest of dam.

The following data have been used in connection with designing an ›verflow concrete dam for the spillway:

The area of watershed is 50 square miles. Assuming the highest ›robable flood discharge at 100 second-feet per square mile, we have ›,000 second-feet flood discharge. It is desirable to have the surface evel of the reservoir at the 180-foot contour (based upon an assumed latum), which, therefore, will be the level of lip of spillway weir. This will give a depth of 120 feet of water in the reservoir. The owest point in the divide where the spillway is to be is at 154 feet elevation. Maximum height to crest of weir, 26 feet; length on top at 185-foot contour, 550 feet; length of weir opening at 180-foot contour, 500 feet. With a depth of water over weir of 2½ feet the discharge capacity will be 6,580 second-feet, and with a depth over weir of 4 feet the capacity will be 13,320 second-feet, and the water level will be within 1 foot of the crest of main dam, the latter case being a most extreme assumption.

Capacity of Briscoe reservoir.

Contour.	Height of dam.	Area.	Capacity between contours.	Total capacity.
Feet.	*Feet.*	*Acres.*	*Acre-feet.*	*Acre-feet.*
70	10	1.7	8.5	8.5
80	20	10.7	62	70.5
90	30	17.2	139.5	210
100	40	30.6	239	449
110	50	53.0	418	867
120	60	71.9	624	1,491
130	70	99.1	855	2,344
140	80	144.8	1,219	3,565
150	90	211.1	1,779	5,344
160	100	271.0	2,410	7,754
170	110	347.8	3,094	10,848
180	120	401.5	3,747	14,595

Elevation of outlet 30 feet above bottom of reservoir.
Elevation of spillway 120 feet above bottom of reservoir.
Capacity, 14,595−210=14,385 acre-feet.

Estimate for dam on Briscoe Creek of type No. 1, concrete dam with wastew[illegible] the north.

SPECIFICATIONS.

Length of dam on crest	[illegible]
Width of crest	[illegible]
Maximum height	[illegible]
Radius of crest	[illegible]
Elevation at base of dam	[illegible]
Elevation at outlet	[illegible]
Elevation at crest of spillway	[illegible]
Elevation at crest of dam	[illegible]
Front slope	[illegible]
Back slope	5 to [illegible]

Capacity of reservoir, 14,385 acre-feet.

Specific gravity of conglomerate, 143 pounds per cubic foot.

COST.

3,186 cubic yards rock, at $1	$3,18[illegible]
12,744 cubic yards concrete, at $10	127,4[illegible]
Spillway, 4,787.8 cubic yards concrete, at $10	47,87[illegible]
Tower and outlet tunnel, complete	8,8[illegible]
Bridge, 15-foot span	[illegible]
Plant and material	10,000
Right of way	1,000
	198,45[illegible]
Engineering and contingencies, 10 per cent	19,84[illegible]
Total	218,281

Cost per acre-foot stored, $15.17.

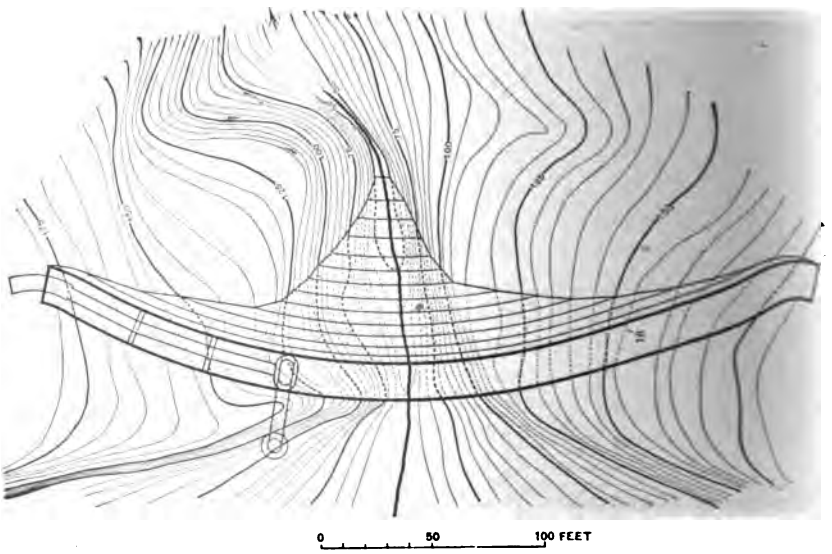


FIG. 8.—Plan of concrete overflow dam, Briscoe reservoir.

BRISCOE CREEK DAM SITE ABUTMENT.

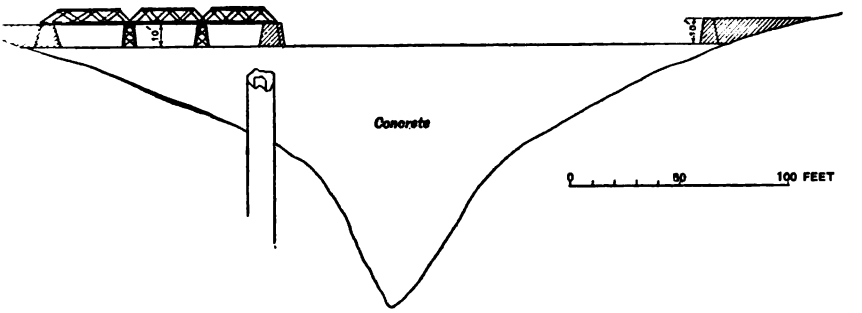


FIG. 9.—Elevation of concrete overflow dam, Briscoe reservoir.

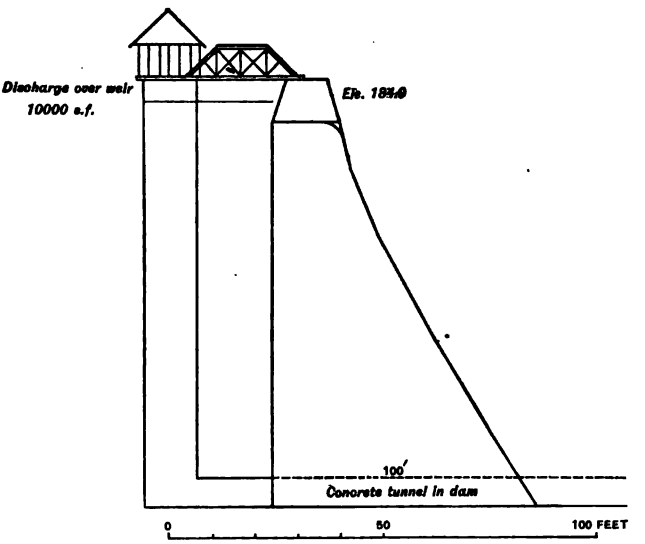


FIG. 10.—Cross section of concrete overflow dam, Briscoe reservoir.

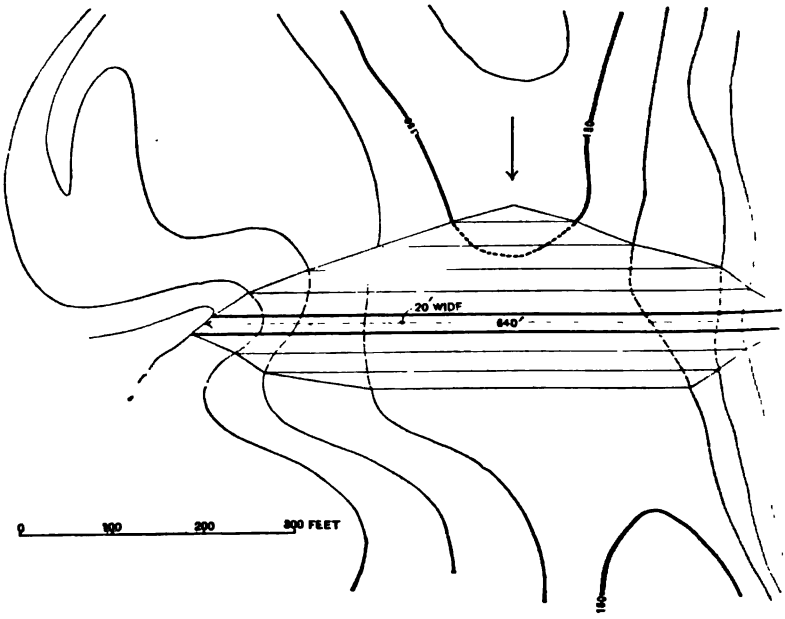


FIG. 11.—Plan of subsidiary earth dam, Briscoe reservoir.

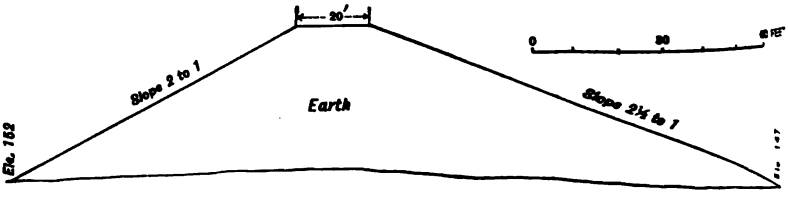


FIG. 12.—Cross section of subsidiary earth dam, Briscoe reservoir.

Estimate of dam on Briscoe Creek, type No. 2, concrete overflow dam, San [illegible] cross section.

SPECIFICATIONS.

Length of dam on crest ..... [illegible]
Width of crest ..... [illegible]
Maximum height ..... [illegible]

COST.

3,572 cubic yards rock, at $1	$3,57[illegible]
14,288 cubic yards concrete, at $10	142,88[illegible]
End walls and bridge pier opposite tower, 349 cubic yards, at $10	3,49[illegible]
Protection along toe of slope (concrete)	5,00[illegible]
Subsidiary dam of earth with cut-off wall of concrete and riprapped on water face	15,80[illegible]
Outlet works, tower, tunnel, bridge along axis of dam to tower	10,08[illegible]

nt and material	$10,000.00
ght of way	1,000.00
	191,914.50
gineering and contingencies, 10 per cent	19,191.45
Total	211,105.95

Cost per acre-foot stored, $14.67.

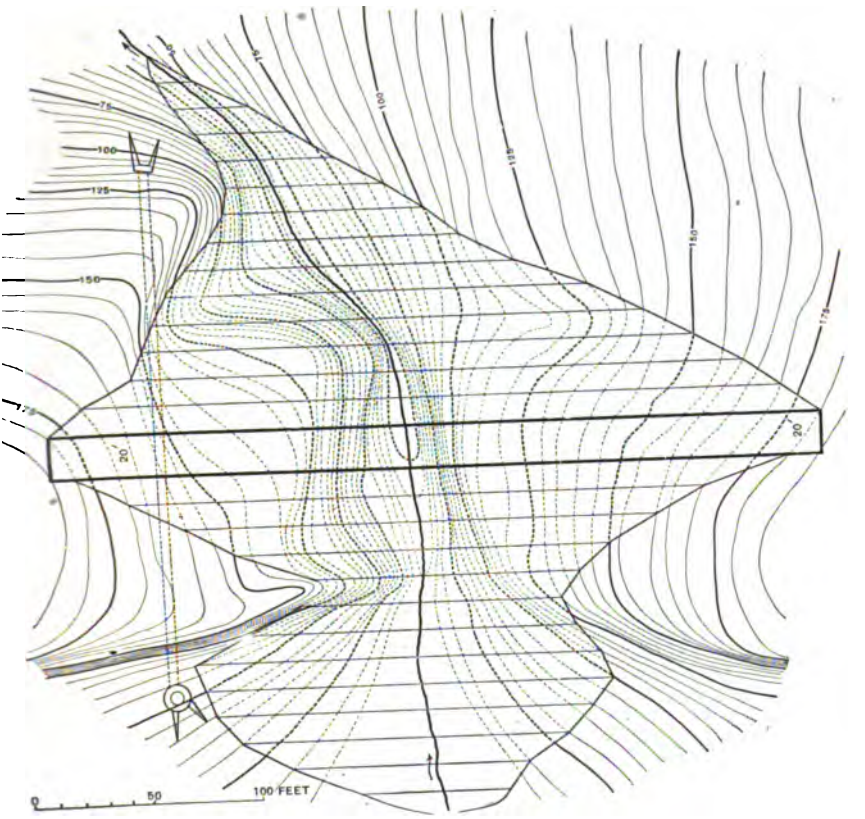


FIG. 13.—Plan of rock-filled dam, Briscoe dam site.

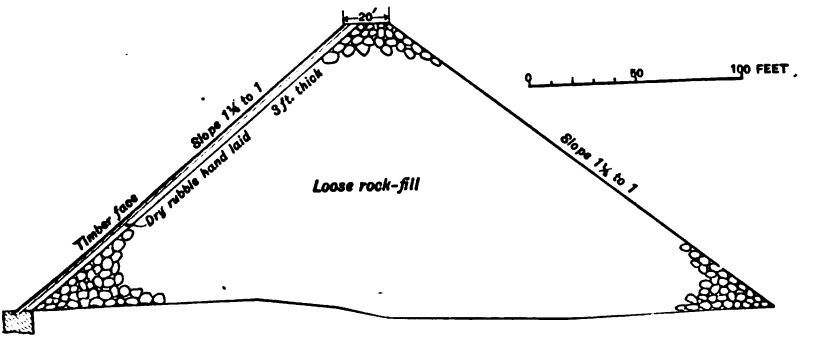


FIG. 14.—Section of rock-filled dam, Briscoe dam site.

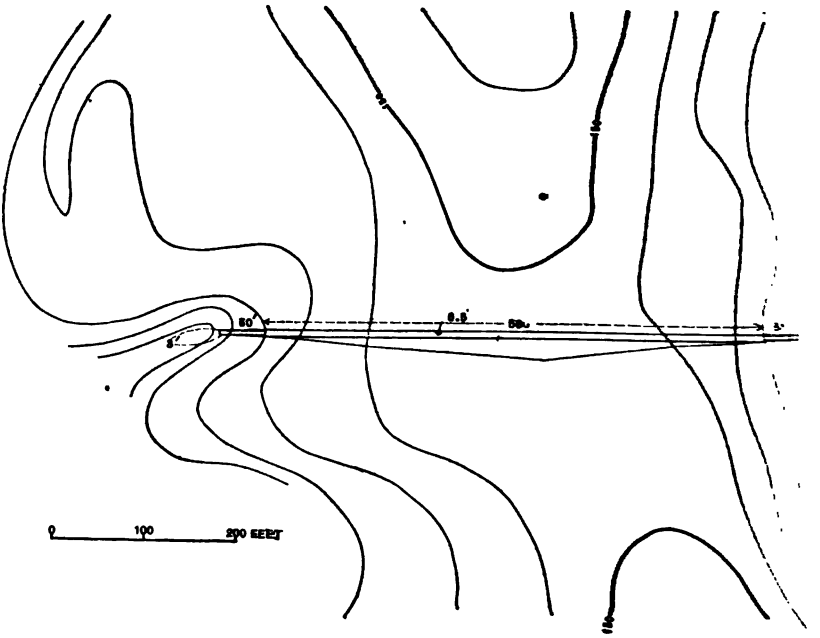


FIG. 15.—Plan of spillway, Briscoe dam site.

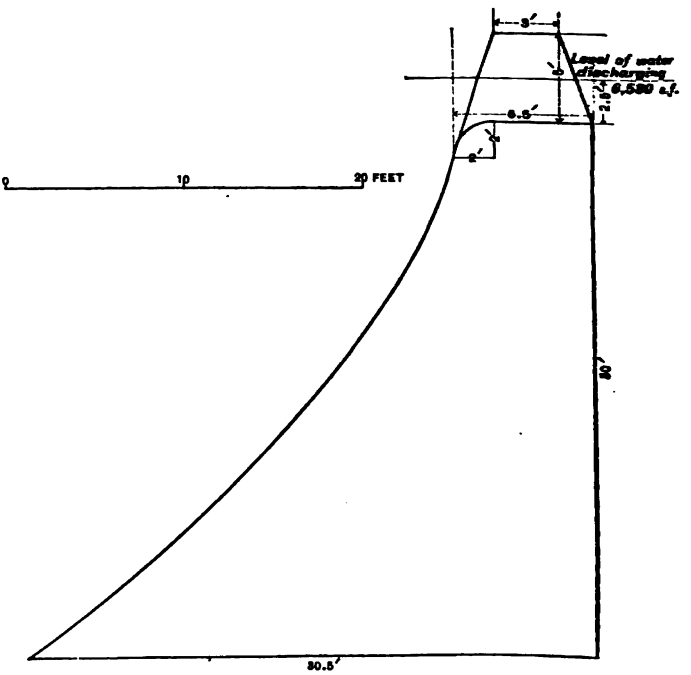


FIG. 16.—Section of spillway, Briscoe dam site.

A. EAST PARK DAM SITE ON LITTLE STONY CREEK.

B. WEST HALF OF EAST PARK RESERVOIR SITE.

Estimate of dam on Briscoe Creek, type No. 3, loose rock dam.

SPECIFICATIONS.

	Feet.
gth of dam on crest	360
lth of crest	20
ximum height	125
ver slope	1¼ to 1
ver slope	1¼ to 1

COST.

56 cubic yards loose rock, at $1	$78,856
ber face, 270,000 feet, at $25 a thousand	6,750
crete filling between stringers, 930 cubic yards, at $10	9,300
rubble wall under plank face, 3 feet thick, 3,744 cubic yards, extra st, at $1.50	5,566
avation for concrete cut-off wall: 370 cubic yards, at $2, $740; 1,130 ubic yards, at 75 cents, $848	1,588
crete to bed rock under plank face, 1,500 cubic yards, at $10	15,000
ver and tunnel outlet, 100-foot span Pratt truss bridge, etc	11,000
llway same as for type No. 1	47,878
nt and material	10,000
ght of way	1,000
	186,938
gineering and contingencies, 10 per cent	18,694
Total	205,632

Cost per acre-foot stored, $14.29 +.

Type No. 1 is recommended for this site as possessing the most atures suitable to the locality and conditions.

Type No. 2 is not considered very safe owing to the converging ape of the narrow canyon at the toe of outer slope which would er immense resistance to the flood water discharging over dam, and e character of the rock is such that it would be liable to give way nder the impact.

Type No. 3 is not recommended because of the unstable character a plank water face and the ultimate necessity of replacing.

It is expected that 14,385 acre-feet of water will be available in the riscoe reservoir in ordinary years. Below this dam in the Stony reek Valley lies a body of land which at present is being used almost xclusively for grain farming, but which would with irrigation produce eciduous fruits and alfalfa at a much greater profit.

LITTLE STONY CREEK, EAST PARK RESERVOIR SITE.

At a point on Little Stony Creek about 2 miles southeast of Stony ord, in Colusa County, a reservoir site was found and surveyed. The sult shows that a dam to the 85-foot contour would give an available supply of 26,000 acre-feet of water. The drainage area above e dam is quite extensive but of relatively low elevation. From the eager rainfall records it is estimated that a mean annual draft of

26,000 acre-feet can be obtained from this reservoir. In order to obtain information as to the run-off available from this and other tributaries of Stony Creek the gaging station at Julian's ranch was established and is being maintained. Two types of dams have been designed for this location, corresponding to types Nos. 1 and 2 at Briscoe site.

Capacity of East Park reservoir.

Height of dam.	Area.	Capacity between contours.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
0	0	0	----------
10	2.28	11.4	11.4
20	44.19	232.5	243.9
25	----------	----------	654.3
30	119.97	820.8	1,064.7
40	254.86	1,874.1	2,938.8
50	478.14	3,665.0	6,603.8
60	640.49	5,593.2	12,197.0
70	1,100.36	8,704.3	20,901.3
75	1,240.67	5,852.6	26,753.9

Elevation of outlet, 25 feet.

Elevation of spillway, 75 feet.

Total capacity in acre-feet above outlet at 25-foot contour and up to 75-foot contour, 26,753.9—654.3=26,099.6; 26,000 acre-feet was used as capacity of reservoir.

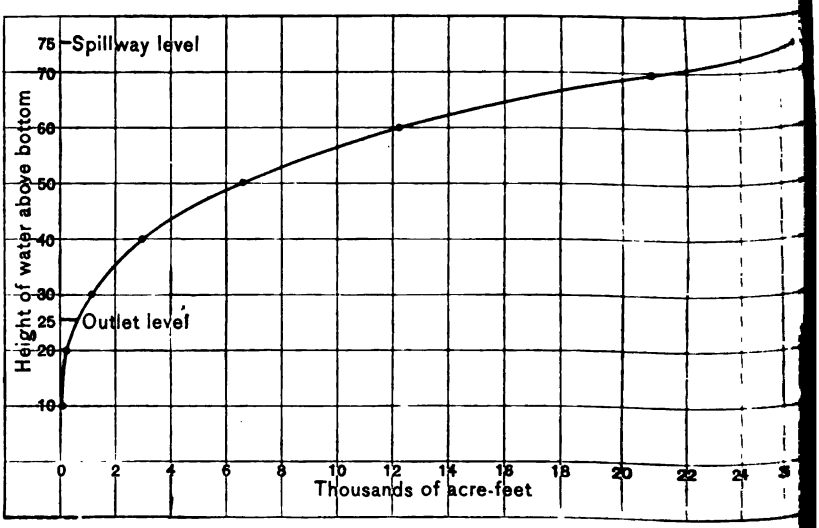
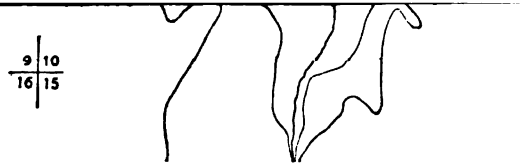
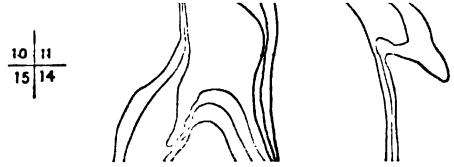


FIG. 17.—Capacity curve, East Park reservoir.


9 10
16 15


10 11
15 14

11 12
14 13

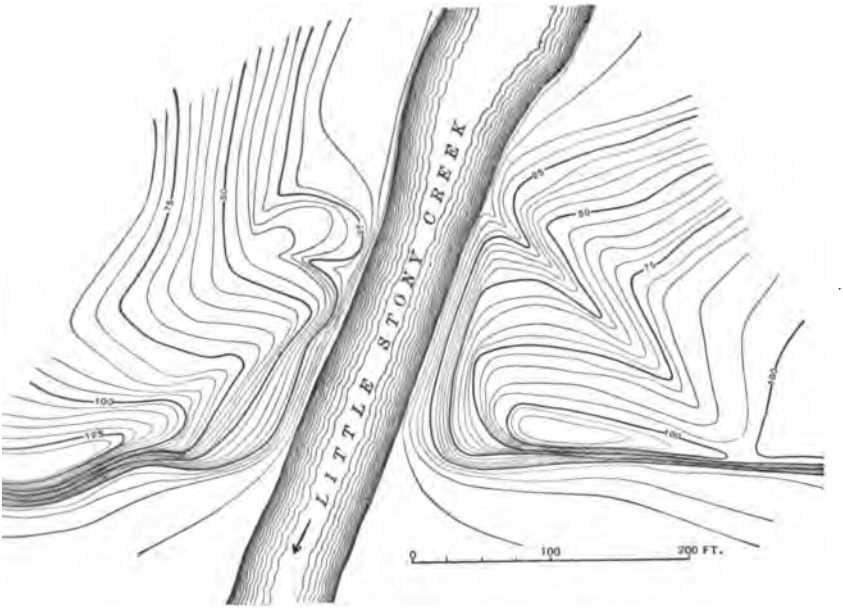


FIG. 18.—East Park dam site.

Estimate for dam on Little Stony Creek, type No. 1, concrete dam.

SPECIFICATIONS.

	Feet.
atter of water face	5 in 100
atter of lower face	1 in 2
levation of crest of dam	85
stimated elevation of base of dam	--30
laximum height of dam	115
levation of sill of spillway	75
levation of outlet	25

Capacity of reservoir, 26,000 acre-feet.

Capacity of spillway (water 2 feet below crest of dam), 15,070 cubic feet per econd.

COST.

3,900 cubic yards concrete, at $10	$139,000.00
Excavation to bed rock	6,000.00
pillway	3,285.00
Outlet tunnel and works	7,876.00
Bridge	720.00
Cable machinery	10,000.00
Lumber in flumes, etc., 10,000 feet B. M., at $20	200.00
Right of way	20,700.00
	187,781.00
Engineering and contingencies, 10 per cent	18,778.10
Total	206,559.10

Cost per acre-foot stored, $7.94.

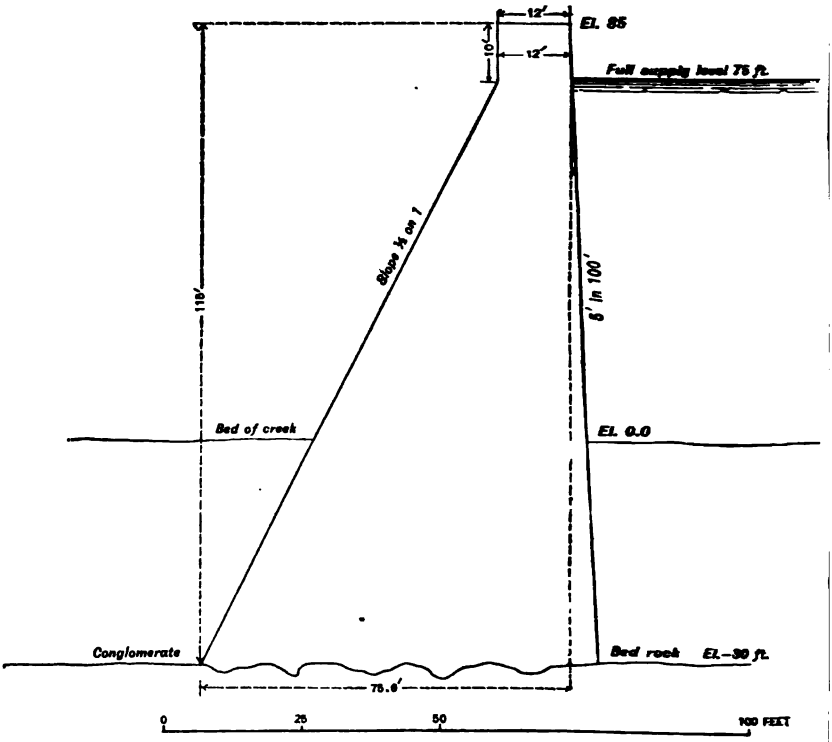


FIG. 19.—Maximum cross section of concrete dam, East Park dam site.

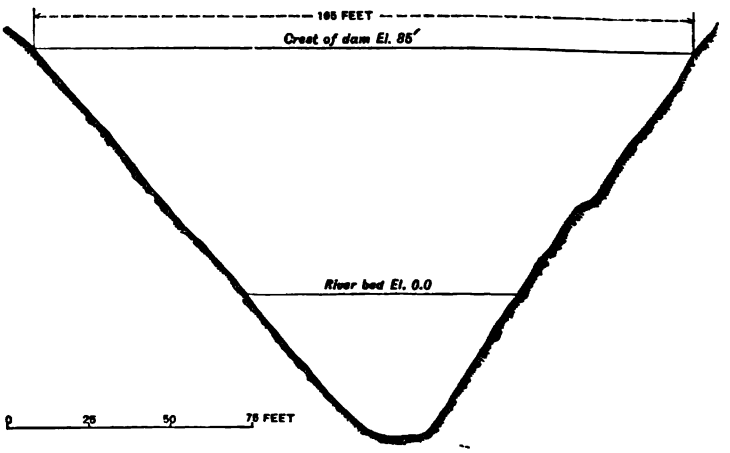


FIG. 20.—Profile of dam site, East Park dam site.

A. CONGLOMERATE AT EAST PARK.

B. MILL SITE DAM SITE ON STONY CREEK.

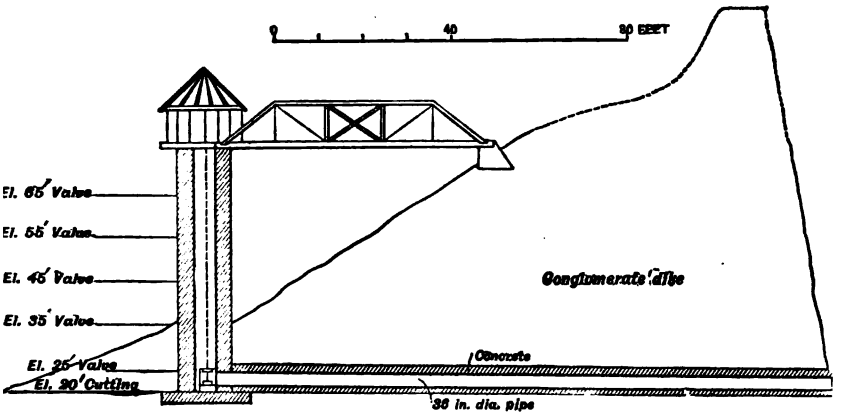


FIG. 21.—Outlet tunnel, East Park dam site.

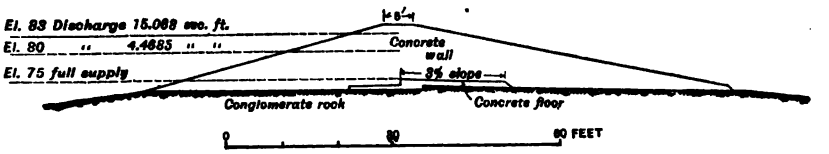


FIG. 22.—Profile of spillway, concrete dam, East Park dam site.

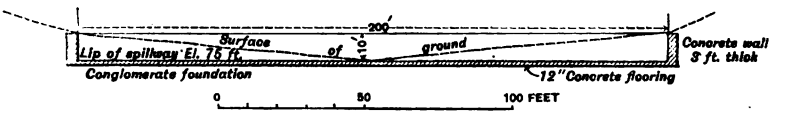


FIG. 23.—Cross section of spillway, concrete dam, East Park dam site.

Estimate of cost of rock-filled dam on Little Stony Creek. Type No. 2.

32,700 cubic yards, at $1.25	$65,875.00
Excavation to bed rock, 2,000 cubic yards, at $2	4,000.00
Concrete to bed rock, 1,500 cubic yards, at $10	15,000.00
Plank face, 170,000 feet B. M., at $25 a thousand	4,250.00
Concrete between stringers under planks, etc., 481 cubic yards, at $10	4,810.00
Concrete valve tower and bridge	7,040.00
Tunnel and concrete filling	1,850.00
Wasteway	18,250.00
Dry rubble foundation under timber, 1,444 cubic yards, at $1.50 (extra cost)	2,166.00
Cable machinery	10,000.00
Right of way	20,700.00
	153,941.00
Engineering and contingencies, 10 per cent	15,394.00
Total	169,335.00

Cost per acre-foot stored, $6.51.

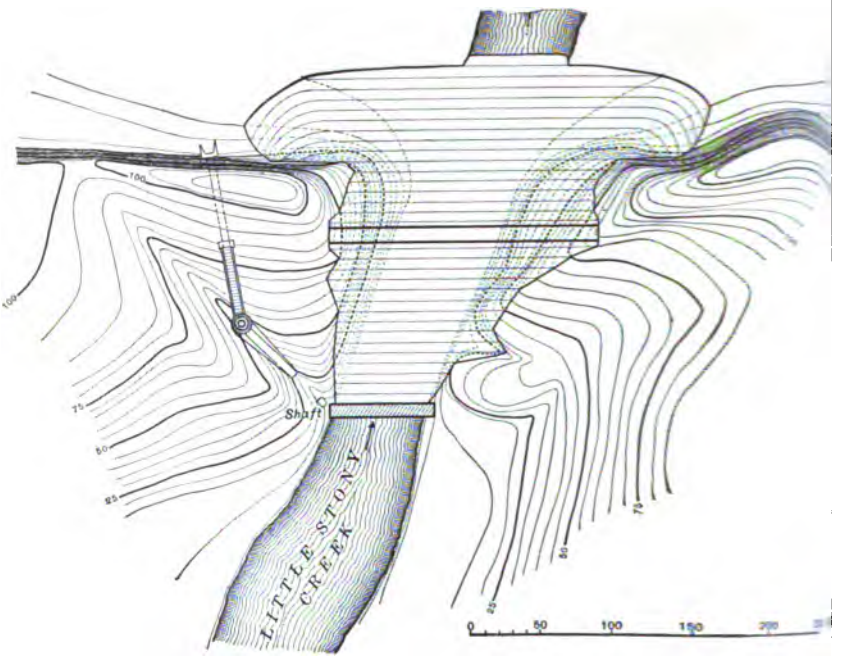


FIG. 24.—Plan of rock-filled dam, East Park dam site.

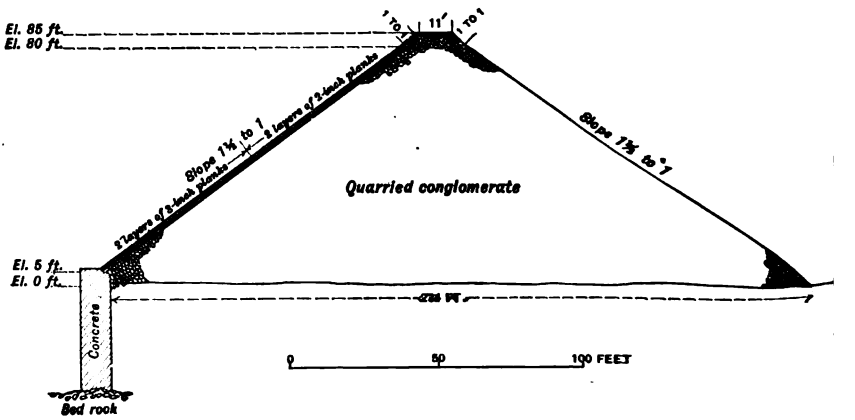
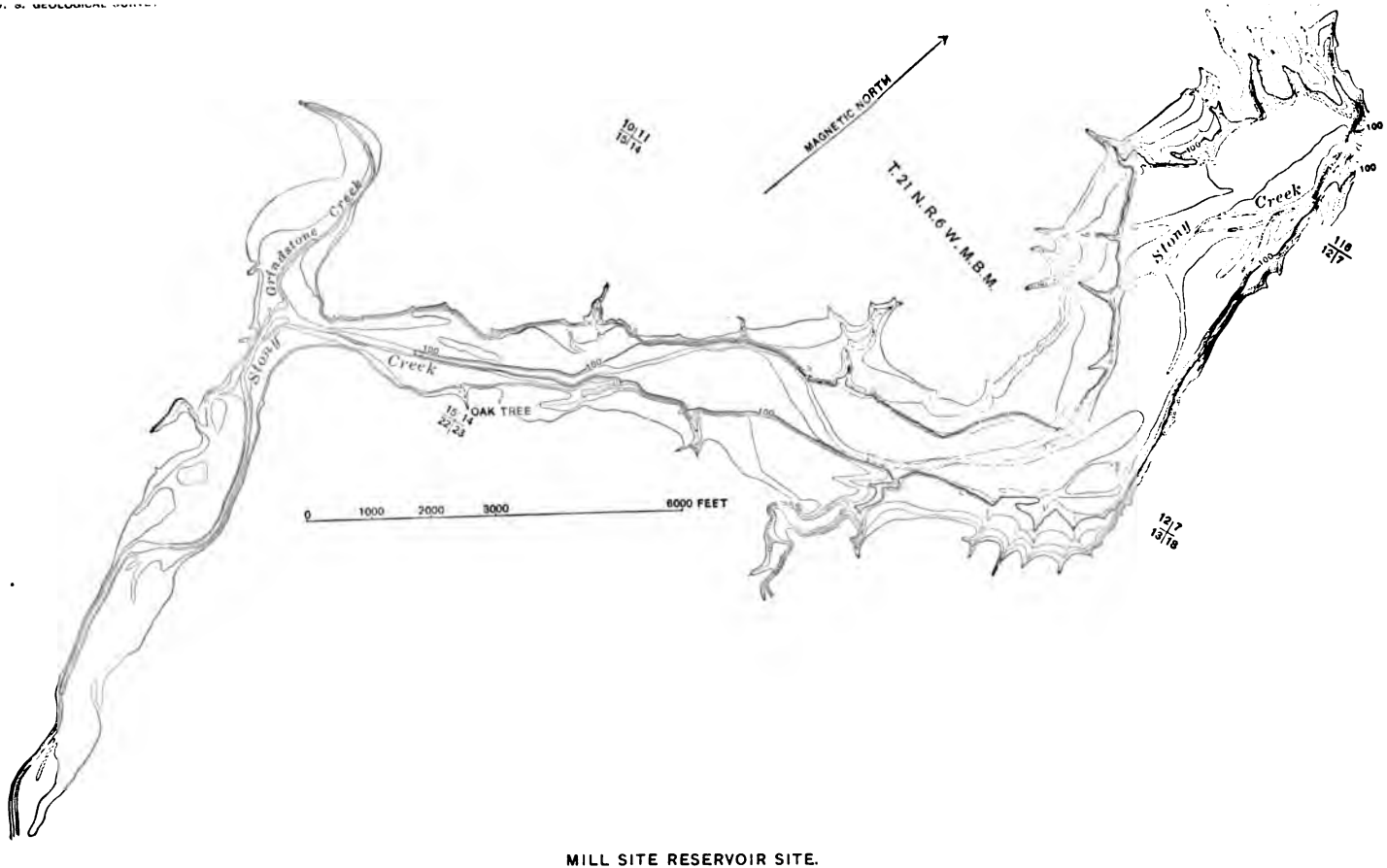


FIG. 25.—Maximum cross section of rock-filled dam, East Park dam site.

Type No. 1 is recommended for this location as being more [illegible] stantial and serviceable than a rock-fill type.

There is a scarcity of sand at the dam sites on Little Stony Cr[illegible] and the cost of concrete has been estimated upon the basis that the [illegible] glomerate rock will have to be crushed and washed for use in p[illegible] of sand. It is thought from inspection that the conglomerate is h[illegible] enough to make good sand, which can be ground to a uniform gr[illegible] and thoroughly washed under pressure in a revolving cylinder.



MILL SITE RESERVOIR SITE.

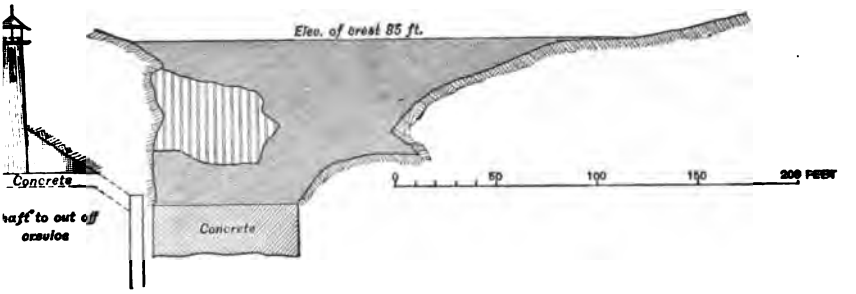


FIG. 26.—Downstream elevation, rock-filled dam, East Park dam site.

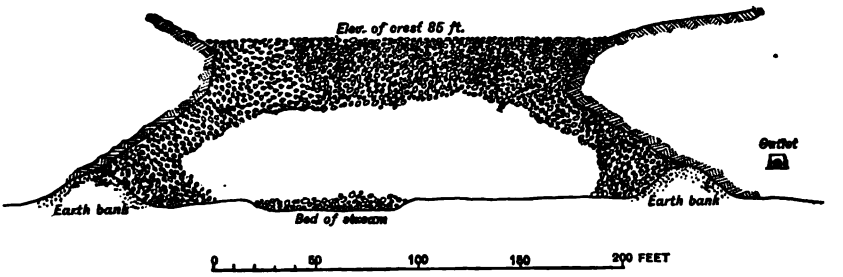
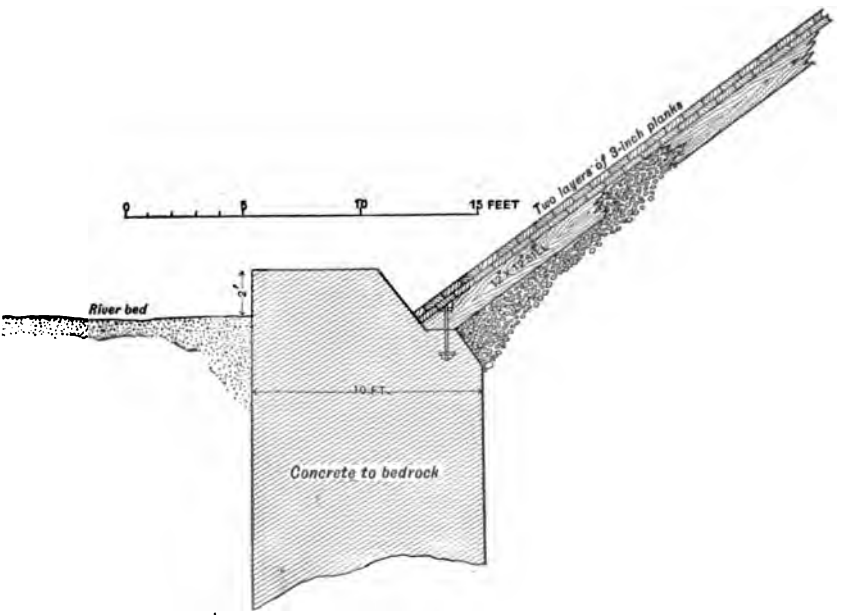


FIG. 27.—Upstream elevation, rock-filled dam, East Park dam site.



G. 28.—Detail of plank face, rock-filled dam, East Park dam site.

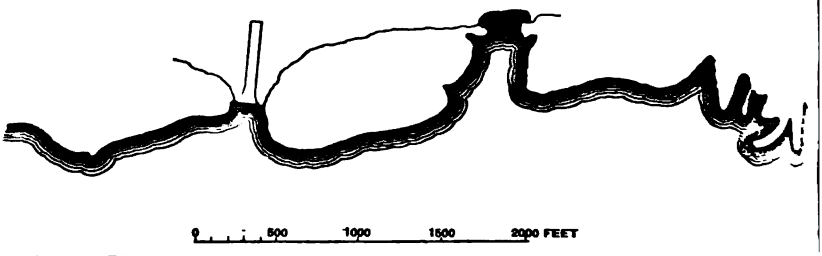


FIG. 29.—Plan showing relative position of wasteway, rock-filled dam, East Park dam site.

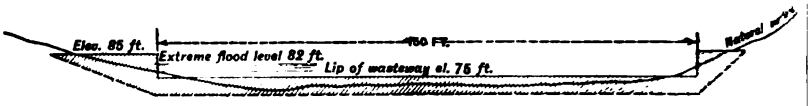


FIG. 30.—Cross section of wasteway, rock-filled dam, East Park dam site.

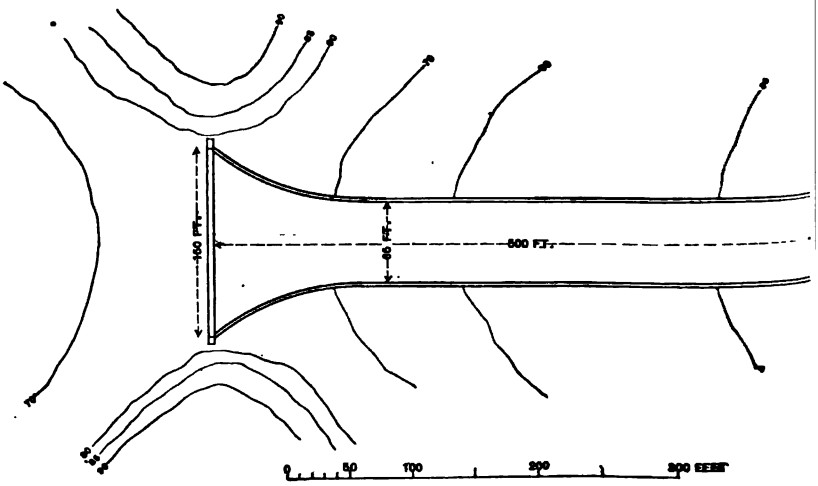


FIG. 31.—Plan of wasteway, rock-filled dam, East Park dam site.

The following figures have been used to estimate the cost of c crete in this locality:

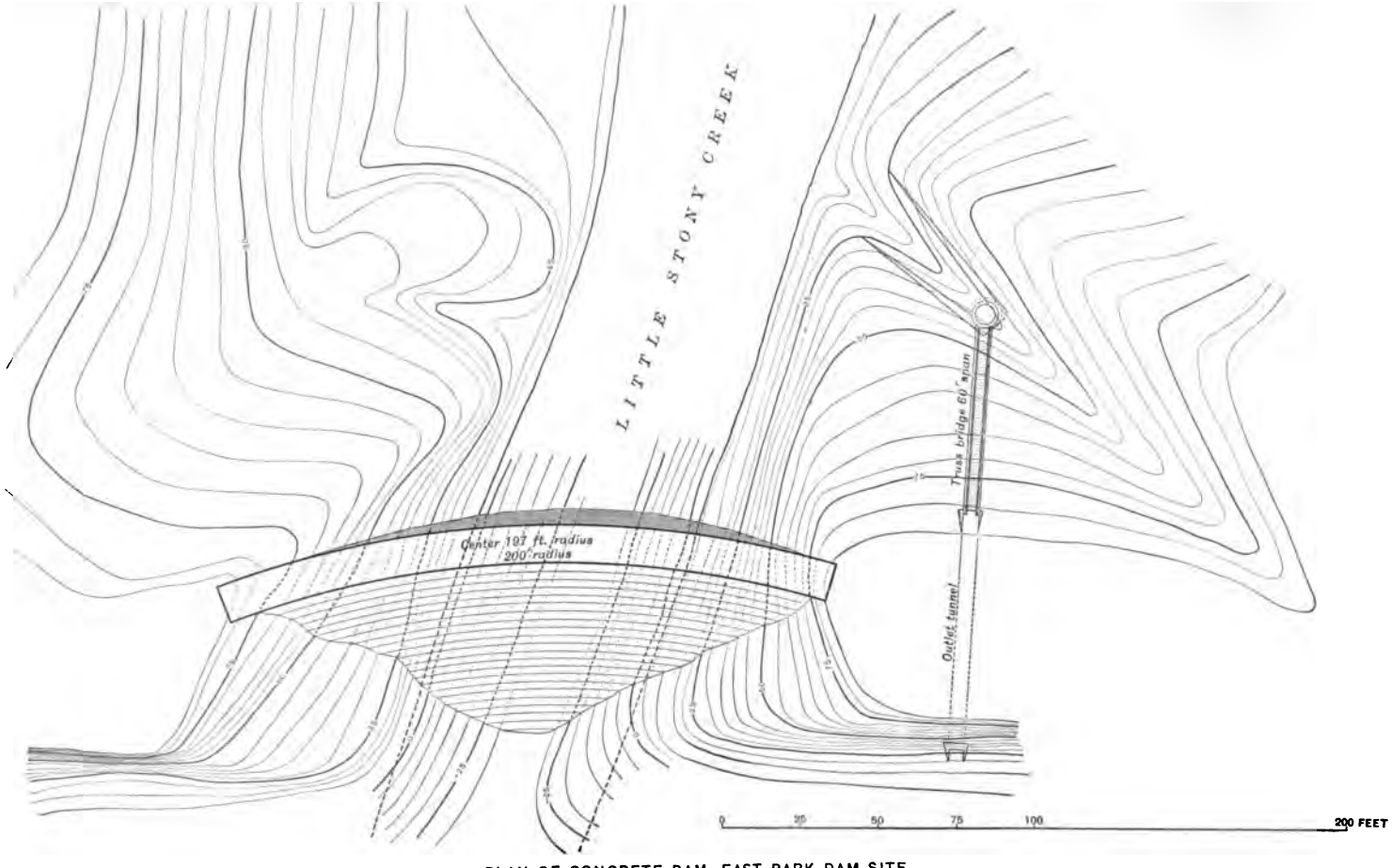
Cost of concrete at Little Stony Creek.

CEMENT.

1 barrel Portland cement, at railroad	$3.75
Freight to dam, at 20 cents per 100 pounds	.80
Cost delivered, per 375 pounds	[illegible]

PLANT FOR PREPARING CONCRETE.

Mill for crushing rock	1.50
Mill for grinding coarse sand	1.50
Engine and boiler	1.00
Freight and setting up	.50
Plant for preparing sand and rock for concrete	4.50
Machine for washing	1.00



PLAN OF CONCRETE DAM, EAST PARK DAM SITE.

PREPARING ROCK AND SAND.

ock, crushing, per cubic yard	$1.50	
ock, washing, per cubic yard	.15	
		$1.65
nd, grinding, per barrel	.36	
nd, washing, per barrel	.14	
		.50

TOTAL COST PER YARD OF CONCRETE.

ock, 1 cubic yard	1.65
nd, 2 barrels, at 50 cents	1.00
ement, 1 barrel	4.55
abor, mixing	.50
abor, placing in dam	1.00
llow for machinery	.30
ontingencies	1.00
Estimate total cost, per yard	10.00

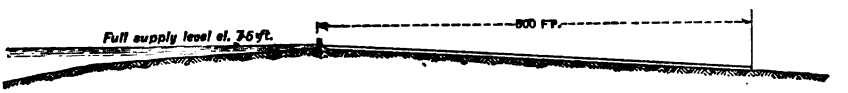


FIG. 32.—Profile of wasteway, rock-filled dam, East Park dam site.

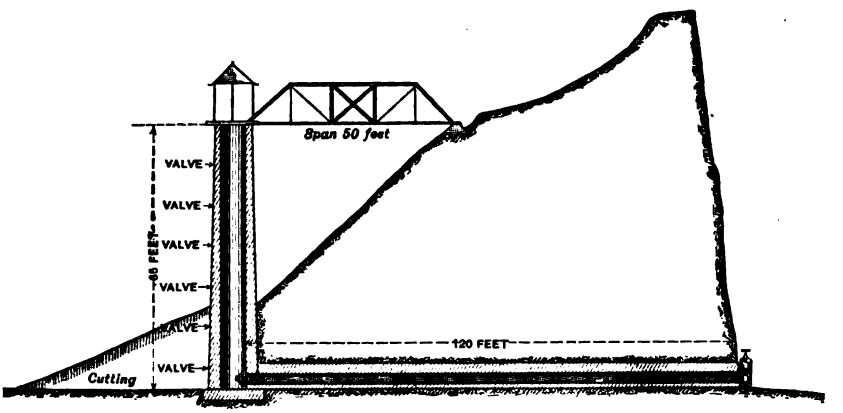


FIG. 33.—Outlet of tunnel, rock-filled dam, East Park dam site.

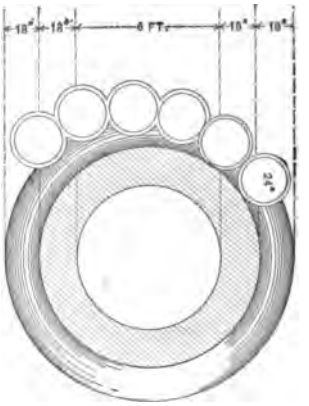


FIG. 34.—Plan of valves, rock-filled dam, East Park dam site.

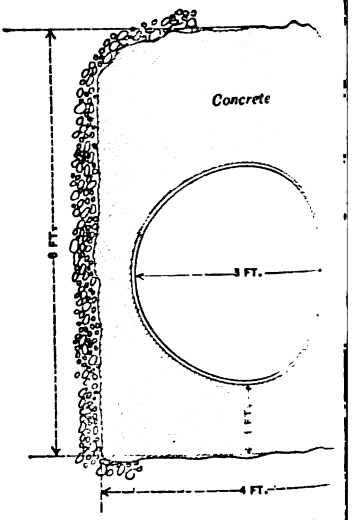


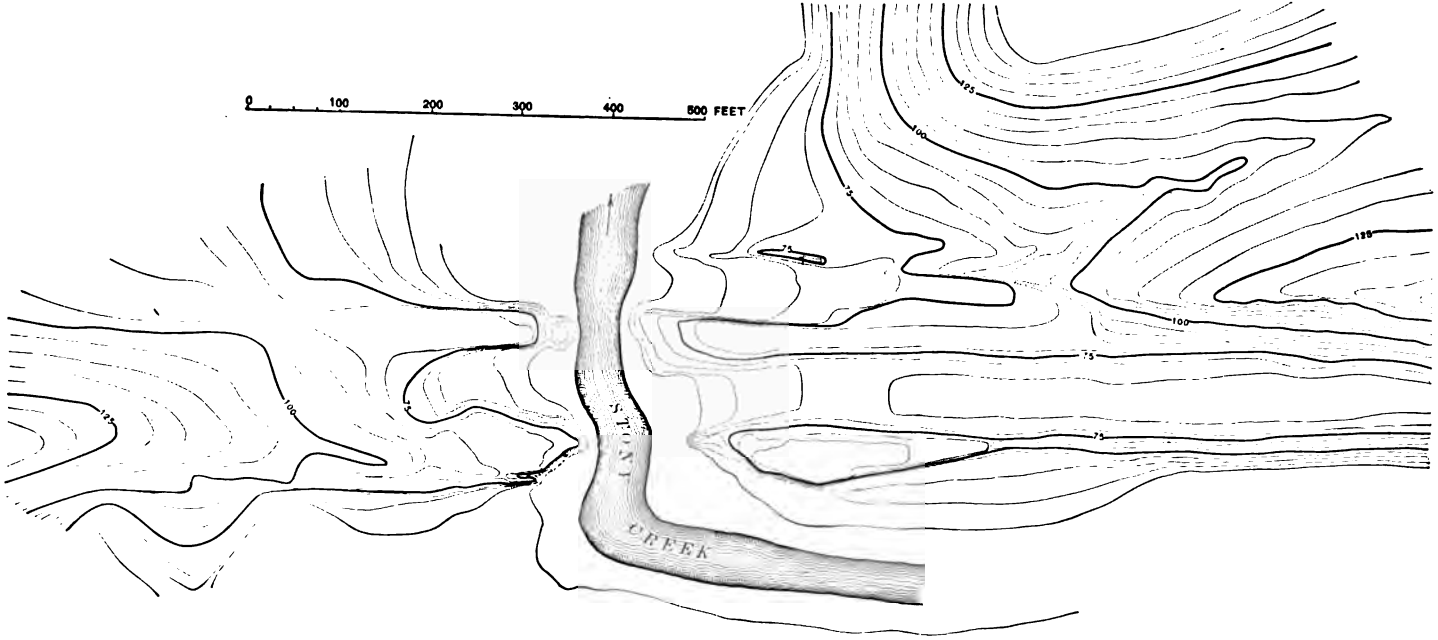
FIG. 35.—Tunnel cross section, rock-filled dam, East Park dam site.

MILL SITE.

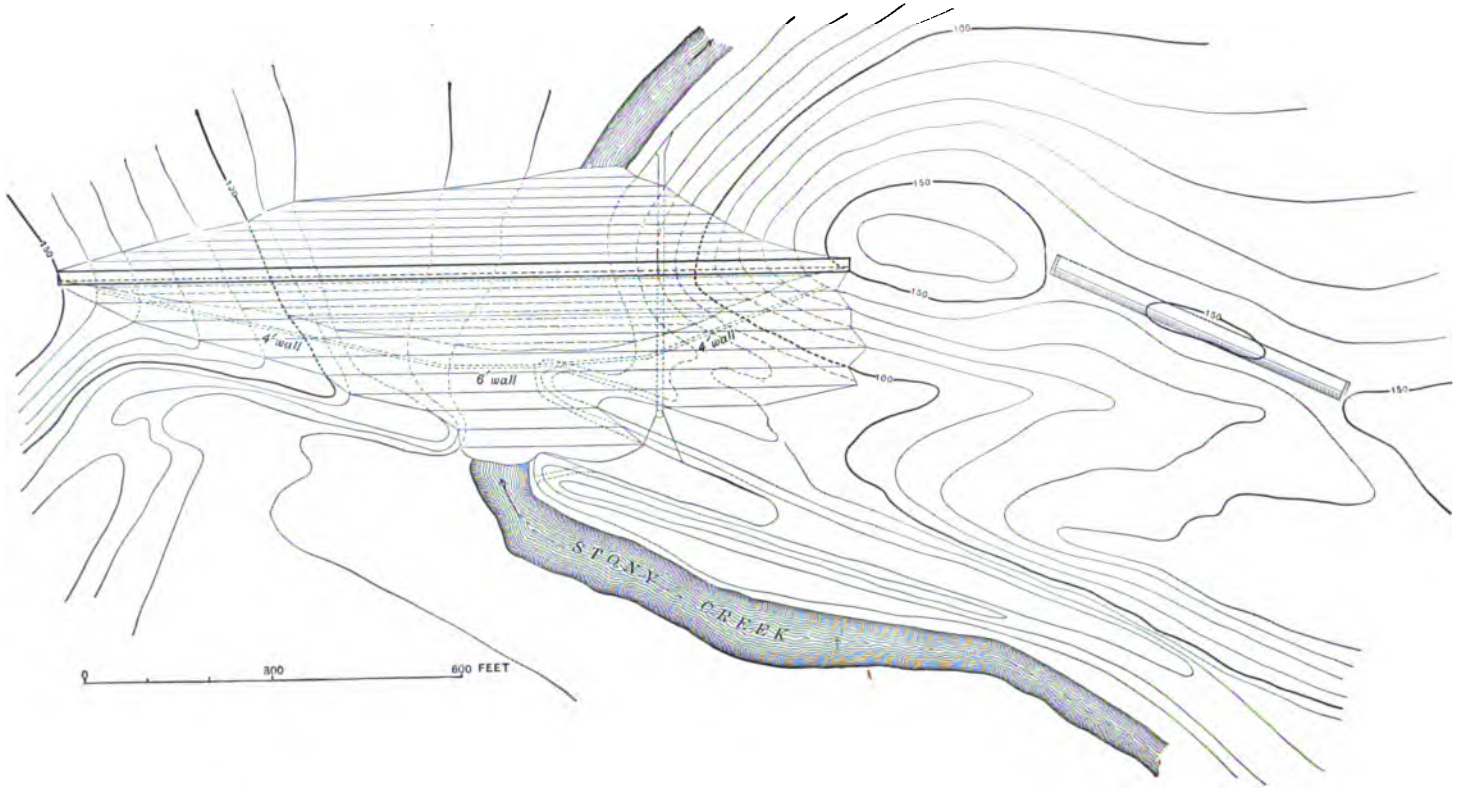
At a point on the main creek in sec. 1, T. 21 N., R. 6 W., Mt. Diablo meridian, locally known as the "Mill Site," the main stream intersects a conglomerate bed.

As it is near the Sacramento Valley, and has back of it over square miles of drainage area, exclusive of Briscoe and Little Stony creeks, this site is relatively important. A dam at this point, feet above the stream bed, would impound 43,735 acre-feet of water. The drainage area above the site is such that it is estimated that amount of water would be available even in dry years. A record the flow has been kept at Julian's ranch at a point 1¾ miles above dam site; the estimated discharge for 1901 and 1902 is shown by table on p. 35. The depth to bed rock is assumed to be 35 feet. soundings were made to determine this.

The wall rock is not very good, and material for concrete would have to be transported 1,600 feet. Owing to these conditions it was decided to estimate on a loose or rock-filled dam with ample spillway. The dam designed has a top length of 1,240 feet, upper slope 1 to 1¼; lower slope 1½ to 1; the upper slope is to be faced with an earth embankment built against it with a slope of 3 to 1, the width of the rock on top to be 15 feet and the earth 5 feet, making the finished crest 20 feet wide. The spillway, calculated to carry 36,250 second-feet of water when flowing 8 feet deep over the sill, is 500 feet wide by 10 feet deep and would be located to the east of the dam through a low saddle and discharge several hundred feet below the dam.



MILL SITE DAM SITE, ROCK-FILLED DAM.



PLAN OF MILL SITE DAM.

Estimate of cost of rock-fill dam at Mill Site.

8,400 cubic yards earth and selected material, at 75 cents per cubic yard		$148,800
3,200 cubic yards loose rock to be transported, average 1,600 feet, at $1		293,200
oncrete cut-off wall, 2,836 cubic yards, at $10	$28,360	
xcavation, 1,452 cubic yards, at $2	2,904	
xcavation, 951 cubic yards, at 50 cents	476	
		31,740
pillway, 500 feet wide 10 feet deep:		
Excavation, 13,160 cubic yards, at 40 cents	5,264	
Concrete wall and apron for weir, 875 cubic yards, at $10	8,750	
		14,014
utlet tunnel, 400 feet, at $10		4,000
ower, 90 feet, 1.7 cubic yards per foot, 153 cubic yards, at $10		1,530
alves and appliances		3,000
oncrete dam in tunnel, 100 feet, 85 cubic yards, at $10		850
0 feet 48-inch pipe and gate attached		2,000
ridge for tower, 225 feet span, Pratt truss		3,000
3,340 cubic yards riprapping, at $1.50 (additional charge)		27,510
		529,644
) per cent for contingencies and engineering		52,964
Total		582,808

Cost per acre-foot stored, $13.32.

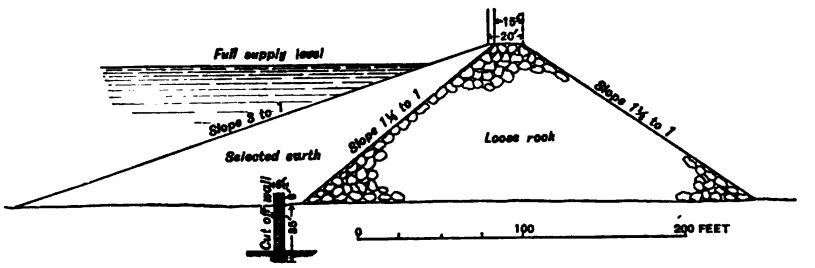


FIG. 36.—Section of Mill Site dam.

Capacity of Mill Site reservoir.

Contour.	Height of dam.	Area.	Capacity between contours.	Total capacity.
Feet.	*Feet.*	*Acres.*	*Acre-feet.*	*Acre-feet.*
55	0	0	0	0
60	5	25.9	130	65
70	15	117.1	715	780
80	25	268.3	1,927	2,707
90	35	398.2	3,333	6,040
100	45	504.6	4,514	10,554
110	55	629.4	5,670	16,224
120	65	798.4	7,139	23,363
130	75	1,029.1	9,137	32,500
140	85	1,231.2	11,300	43,800

Elevation of outlet, 5 feet above bottom of reservoir.
Elevation of spillway, 85 feet above bottom of reservoir.
Capacity, 43,800—65=43,735 acre-feet.

This water would be used to irrigate the rich foothill lands on west side of the Sacramento Valley between Orland and Willows.

In the judgment of the county assessor, who has an intimate kn edge of the nature of the land in Glenn County, these lands would easily advanced $30 per acre in value if furnished with ample w supply.

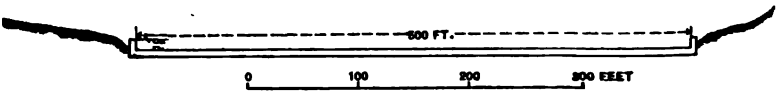


FIG. 37.—Section of spillway, Mill Site dam.

The capacity of the Mill Site reservoir not being sufficient impound all of the flow of Stony Creek, a further investigation made in February, 1901, of the feasibility of diverting a portio this water into Hambright and Eppinger creeks, small streams r in the foothills and discharging into the Sacramento Valley. Cer reservoir sites exist on those streams too large to be filled from t drainage basins. The result of this investigation indicated that cost of the diversion-canal line would be too heavy and the reser capacity not sufficient to justify the necessary expense incident this construction.

ALFALFA FIELD, BROWN'S RANCH, STONY CREEK VALLEY.

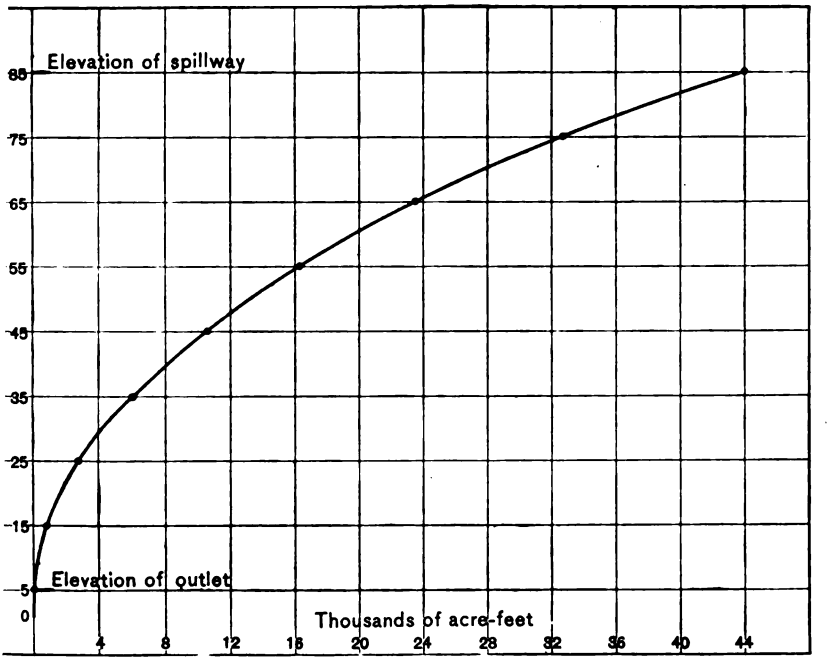


FIG. 38.—Capacity curve, Mill Site reservoir.

SUMMARY.

The annual cost per acre-foot of water stored is the important ·ult to obtain, and this is shown by the accompanying table for each ·ervoir and for each class of dam estimated upon.

Cost and capacity of reservoirs on Stony Creek.

ıprovement.	Description.	Area of watershed.	Length of dam on crest.	Width of crest of dam.	Capacity.	Cost of installation.		Annual cost per acre-foot of water stored for interest and operation.
						Total.	Per acre-foot stored.	
		Square miles.	*Feet.*	*Feet.*	*Acre-feet.*			
·scoe reser-oir.	125-foot concrete gravity dam with wasteway.	50	360	12	14,385	$218,281.80	$15.17+	$1.10
	120-foot concrete overflow dam.	50	360	16	14,385	211,105.95	14.67+	1.07
	125-foot loose rock-fill dam with wasteway.	50	360	20	14,385	205,632.00	14.29+	1.09
·st Park res-rvoir.	115-foot concrete gravity dam with wasteway.	210	197	12	26,000	206,559.10	7.94	.58
	115-foot loose rock-fill dam with wasteway.	210	195	20	26,000	169,335.00	6.51	.50
ll Site reser-·oir.	95-foot loose rock-fill dam with wasteway.	500	1,240	20	43,735	582,608.00	13.32	.98

As it is not determined just where the water will be used, by seepage and evaporation in the canals can not be estim. Evaporation from the surface of reservoirs for the months of July, August, and September would probably be from 3 to 5 per of the capacity of the reservoir, and in these estimates has neglected.

The life of the plank face in the case of the rock-fill dams has taken as eight years.

To illustrate particularly the method of arriving at the cos acre-foot of water delivered, the Mill Site reservoir will be tak an example. Consider the entire cost, $582,608, to bear 6 per interest, and taxes to be at the rate of 0.8 of 1 per cent of cos the charge for attendance, etc., to be $1,000 per annum, the a charges to be provided for would be $40,617.34. The ava capacity of the reservoir is 43,735 acre-feet. This, divided into annual charge of $40,617.38, gives as the annual cost per acre-fo water delivered from the reservoir 93 cents.

CONCLUSIONS.

The following conclusions may be drawn from the preceding tables, and estimates:

(1) The lands of portions of Glenn and Colusa counties steadily decreased in value, fertility, and population for the la years.

(2) The lands on the west side of the Sacramento Valley i vicinity of Orlando and Willows need irrigation and would be at increased in value at least $30 per acre if a permanent water s were assured, and the land values and population would ste increase under irrigation.

(3) The climatic conditions are favorable for the growth of and nearly all the products of the State in this vicinity.

(4) Several commercially valuable reservoir sites exist in the w shed of Stony Creek and its tributaries.

(5) The annual run-off is sufficient to fill these reservoirs in of average rainfall. In the case of the Mill Site reservoir the s is many times greater than the capacity of the reservoir. T would probably not be sufficient run-off to fill the Briscoe Cre Little Stony Creek reservoirs in years of very low rainfall.

(6) The cost per annum per acre-foot of water stored in the re voirs ranges from 50 cents to $1.10.

(7) The conditions are favorable for long life of the reservoi account of the small amount of silt and débris carried by the str

INDEX.

Page.

lfa field, Brown's ranch, Stony Creek Valley, plate showing . 58
lett Springs, precipitation at 23
k Butte and Stony Creek gaging station, plate showing 22
coe Creek, dam of various types on, estimates for 42, 44, 45, 47, 59
lams on 37-47
coe Creek dam site, plate showing ... 38
coe Creek dam site abutment, plate showing 42
coe Creek reservoir site, plate showing 40
coe dam site, figure showing 37
rock-filled dam, plan of, figure showing 45
section of, figure showing 45
spillway, plan of, figure showing 46
section of, figure showing 46
scoe reservoir, capacity curve, figure showing 38
capacity of 41, 59
concrete dam, plan of, figure showing. 38
section of, figure showing 39
concrete overflow dam, cross section of, figure showing 43
elevation of, figure showing 43
plan of, figure showing 42
spillway, plan of, figure showing 40
section of, figure showing 40
subsidiary earth dam, cross section of, figure showing 44
plan of, figure showing 44
mp Wright, precipitation at 24
ntral Irrigation District, canal opposite Jacinto and near St. Johns, plate showing 16
irrigation enterprises and operations in 14-15
possible reorganization of 19
imatic conditions in Sacramento Valley and in northern Italy, comparison of 11
imate of Sacramento Valley 28
ncrete at Little Stony Creek, cost of .. 54-55
rning, climatological data for 28
ast Park, conglomerate at, plate showing 50
ast Park dam site, concrete dam, cross section of spillway, figure showing 51
concrete dam, maximum cross section of, figure showing 50

Page.

East Park dam site—Continued.
concrete dam, plan of, plate showing. 54
profile of spillway, figure showing 51
figure showing 49
on Little Stony Creek, plate showing. 46
outlet tunnel, figure showing 51
profile of, figure showing 50
rock-filled dam, cross section of wasteway, figure showing 54
detail of plank face, figure showing 53
elevation downstream, figure showing 53
elevation upstream, figure showing 53
maximum cross section of, figure showing 52
rock-filled dam, outlet of tunnel, figure showing 55
plan of, figure showing 52
plan of valves, figure showing 56
plans of wasteway, figure showing 54
profile of wasteway, figure showing 55
tunnel cross section, figure showing 56
East Park reservoir, capacity curve, figure showing 48
capacity of 48, 59
East Park reservoir site, description of .. 47-56
plate showing 48
west half of, plate showing 46
Farming conditions in Sacramento Valley 12
Farm-land holdings in Central Irrigation District 13
Fires, forest, in Stony Creek Basin 19-20
Forest reserve, proposed, at head of Stony Creek 20-22
Forests, destruction of, by fire, in Stony Creek Basin 19-20
Fouts Springs, precipitation at 23
precipitation at, figure showing 27
Fruto, temperature at 26
Grindstone Creek, description of 36
Hall, William Hammond, quoted on Central Irrigation District 13
Iron Canyon, Sacramento River at, discharge of 18
Italy, northern, climatic conditions in, comparison of, with those of Sacramento Valley 11
Jacinto, precipitation at 25

Page
Jellys Ferry, Sacramento River at, discharge of 16-18
Julian's ranch, discharge measurements at 33-35
on Stony Creek, gage station at 32
precipitation at 24
Little Stony, precipitation at 24
Little Stony Creek, dam of various types on, estimates for 49, 51
reservoir site on 47-56
Markham, W. H., data from report of, concerning farm-land holdings 13
Mill Site, description and location of 56-59
dam at, estimated cost of 57, 59, 60
importance of 56
Mill Site dam, plan of, plate showing 56
section of, figure showing 57
section of spillway, figure showing 58
Mill Site dam site, on Stony Creek, plate showing 50
rock-filled dam, plate showing 56
Mill Site reservoir, capacity curve, figure showing 59
capacity of 58, 59-60
Mill Site reservoir site, plate showing 52
Newville, reservoir site at 36
Orange tree at Willows, plate showing 10
Orland, climatological data for 28
Paskenta, reservoir near 37
Po, valley of, climatic conditions in, comparison of, with those of Sacramento Valley 11
Population of Colusa and Glenn counties 13
Precipitation, records of 23-26
Red Bluff, precipitation at 30
precipitation at, figure showing 27
Sacramento River at, discharge of 15
temperature at, summaries of 29
thunderstorms at, number of 32
weather at, conditions of 31
Riverside district, irrigation in, results of 13-14
Sacramento River, discharge of, at Iron Canyon .....
discharge of, at Jellys Ferry .....
at Red Bluff .....
difficulty of diverting waters of .....
opposite Willows, plate showing .....
Sacramento Valley, climatic conditions in .....
climatic conditions in, comparison of with those of northern Italy
farming conditions in .....
frosts in, killing, dates of .....
population of .....
proposed forest reserve in .....
rainfall, temperature, and relative humidity in .....
rainfall in, greatest amount of, table showing .....
streams of, fluctuations of .....
water supply of .....
Sacramento Valley Development Association, resolutions by .....
Salt Creek, description of .....
Sand on Little Stony Creek, scarcity of
Stony Creek, discharge of .....
reservoirs on, cost and capacity of
silt carried by .....
storage possibilities of .....
Stony Creek (North Fork), reservoir on
Storage possibilities of Stony Creek Basin
Thomas Creek, possibility of diverting water of .....
Topography of Stony Creek Basin .....
Water and Forest Association, resolutions by .....
Weaverville, precipitation at .....
Willows, climatological data for .....
ranch house and wheat farm in Sacramento Valley near, plate showing .....
temperature at .....
Woodlands, precipitation at .....
precipitation at, figure showing .....
temperature at .....

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

RRIGATION IN INDIA

(SECOND EDITION)

BY

HERBERT M. WILSON

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GOVERNMENT PRINTING OFFICE
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CONTENTS.

	Page.
face	7
face to second edition	9
roduction	11
List of works on Indian irrigation	25
APTER I.—Finance and statistics	29
Value and necessity of irrigation	29
Land and crops	35
APTER II.—Topography, meteorology, and forestry	39
Topography and geology	39
Meteorology	43
Forestry	45
APTER III.—History and administration	47
History of irrigation works	47
Administration and legislation	48
APTER IV.—Extent and character of irrigation	56
Classes of works	56
Extent of irrigation	57
Financial and agricultural results	58
APTER V.—Alkali and duty	63
Objections to irrigation	63
Water duty and evaporation	67
APTER VI.—Wells, inundation and deltaic canals	75
Wells	75
Inundation canals	78
Deltaic canals	81
APTER VII.—Perennial canals	88
Source of supply	88
Ganges canal, Northwest Provinces	89
Lower Ganges canal, Northwest Provinces	93
Agra canal, Northwest Provinces	95
Sirhind canal, Punjab	97
Chenob, Bari Doab, and Western Jumna canals, Punjab	99
Sidhnai canal, Punjab	100
Soane canals	101
Cross section, slope, and alignment	104
Head-works	107
Weirs	109
Scouring sluices	116
Canal regulators	124
Well foundations	130
Escapes	132
Falls and rapids	134
Drainage works	137
Distributaries	144
Methods of applying water	150

CHAPTER VIII.—Storage works
Classes of works
Reservoirs
Mutha project
Nira project
Betwa project
Periyar project
Tansa reservoir
Masonry dams
Design of dams and weirs
Cost of labor and material
Tanks
Ekruk tank
Ashti tank
Tank dams
Combined storage and canal systems
Palar anicut system
Russellkonda tank, Rushikulya project
Zhara Karez irrigation project
CHAPTER IX.
River training and land reclamation:
River conservancy
Land reclamation

ILLUSTRATIONS.

		Page.
PLATE I.	Map of India	11
II.	Aden tanks, Arabia	22
III.	Mot	74
IV.	*A*, Persian wheel; *B*, Paecottah	76
V.	*A*, Kistna anicut, with river in moderate flood; *B*, Head-sluices of eastern channel from Kanigiri reservoir	84
VI.	Kanigiri reservoir escape	86
VII.	Gopalpur bifurcation, Ganges canal	92
VIII.	Sirhind canal system	98
IX.	Soane canal system, Bengal	102
X.	Cross sections of modern weirs	112
XI.	Narora weir, Lower Ganges canal; plan of well foundations	114
XII.	Narora weir, Lower Ganges canal; plan of superstructure	116
XIII.	Head-works, Lower Ganges canal, Narora	120
XIV.	Sinking foundation wells, Nadrai aqueduct, Lower Ganges canal	130
XV.	Asafnagar Falls, Ganges canal	134
XVI.	Solani aqueduct, Ganges canal	138
XVII.	Ranipur superpassage, Ganges canal	140
XVIII.	Rutmoo level crossing, Ganges canal	142
XIX.	Bhatgur dam, Nira system, Bombay	164
XX.	*A*, Vir head-works. Nira system, Bombay; *B*, Kurra aqueduct, Nira canal	168
XXI.	Main and subsidiary weirs, Nira system; Vir in great flood	170
XXII.	Plan of Periyar project, Madras	180
XXIII.	Periyar dam during construction	182
XXIV.	*A*, Foundation, Tansa dam; *B*, Carrying stones to build Tansa dam	186
XXV.	Natives building Tansa dam, Bombay	188
XXVI.	Ekruk tank	204
XXVII.	*A*, Russellkonda head sluice; *B*, Russellkonda dam	216
FIG. 1.	Percolation and evaporation	69
2.	Paecottah	76
3.	Persian wheel	77
4.	Single mot	77
5.	Inundation canal heading in Dund	79
6.	Kistna canal system	84
7.	Plan and profile of Ganges canal, Hardwar to Roorkee	91
8.	Thora Nulla aqueduct, Soane canal	102
9.	Canal cross sections	105
10.	Three ancient weirs	109
11.	Plan of Soane weir	114
12.	Plan of head-works, Soane canals	115
13.	Shutter on Soane weir	116

FIG. 14. Sidhnai weir
15. Sidhnai canal; section of river in line of dam
16. Details of temporary dams, Ganges canal heads
17. Myapur dam, Ganges canal
18. Head-works and weir training works, Ganges canal
19. Dropping the Soane automatic sluices
20. Details of Sidhnai weir
21. Regulating gates, Ganges and Jumna canals
22. Narora weir, Lower Ganges canal, detail of canal sluices
23. Head-works, Ganges canal
24. Regulating gates, Soane canal head
25. Soane canal, automatic sluice gate
26. Ogee and vertical falls, Ganges canal
27. Soane canals, Bengal; arrangement of branches and escape at Dunwar
28. Rapids, Bari Doab canal
29. Cross section of Solani aqueduct, Ganges canal
30. Agra canal, cross section of Kushuk Fall
31. Plan of Rutmoo crossing, Ganges canal
32. Kao Nulla siphon aqueduct, Soane canal
33. Longitudinal section of Nadrai aqueduct, Ganges canal
34. Cross section of Nadrai aqueduct, Ganges canal
35. Plan of distributing head, Mutha canal, Bombay
36. Sasoon superpassage, Sirhind canal
37. Drainage map, showing arrangement of distributaries
38. Standard masonry outlet for distributaries, Punjab
39. Plan of Mutha and Nira irrigation projects, Bombay
40. Plan and cross section of Bhatgur dam, Nira system, Bombay
41. Reinolds automatic weir gate
42. Section of automatic gates and crest Bhatgur dam
43. Detail of automatic gate
44. Plan of head-works, Nira canal, Vir
45. Plan and section of head, Nira canal
46. Nira canal; superpassage at siphon for Jewhar Nulla
47. Betwa project; plan of dam and head-works
48. Cross section, Betwa dam
49. Betwa project, plan of regulator and scouring sluices
50. Automatic drop shutters, Betwa dam
51. Shutter gates, Betwa dam
52. Section of Periyar dam
53. Periyar head-works, plan of dam and escape
54. Tansa dam, Bombay
55. Tansa project, longitudinal section of dam
56. Profile of masonry dam, Molesworth's formula
57. Cross sections, earth and combined dams
58. Map showing Ashti tank
59. Ashti tank dam
60. Ashti dam slips
61. Palar Anicut system
62. Palar Anicut system, plan and cross section
63. Zhara karez irrigation project, Beluchistan
64. Moncha Nulla karez
65. Training works, Lower Ganges canal, Narora
66. Training works, Agra canal, Okhla

PREFACE.

In the following account of some of the more interesting and promi-
ınt irrigation works in India I shall confine my detailed descriptions,
I did my observations, to the works which exist under conditions
milar to those in the United States, and shall refer only briefly to the
her though equally important features of the irrigation problem in
ıdia.

I examined only the principal canals, navigable and nonnavigable,
ıd entirely neglected the deltaic and inundation canals, as there is
ıtle or no probability that such works will ever be constructed in the
nited States. Transportation by railways and wagon roads is so
ısy and general all over our country that there is little likelihood
ır canals will ever be made navigable; accordingly, though I saw
ıd examined several navigable canals, little reference will be made
ı their features. The more important reservoirs and tanks were
ıamined, especially those under construction. Little will be said of
ells, though in the future improved methods of pumping will be used
ı the United States.

India stands preeminent for her gigantic engineering undertakings.
o other country has so vast and so fertile an expanse of territory,
ith such convenient slopes for the construction of canals, and at the
ıme time such an abundant water supply. In general there is great
milarity between the climate and topography of the great northern
lains of India and portions of our arid West, especially the eastern
ope of the Rocky Mountains and the great California Valley. Cen-
al India and the Deccan have many features in common with the
entral portion of the arid region, particularly portions of northern
rizona and southern Utah. The climate is as similar to that of our
Iiddle Western States as is the topography. The average annual pre-
ipitation rarely exceeds 30 inches, while the precipitation during the
utumn, or rabi, crop varies between 2 and 6 inches.

This autumn crop is the one that will be generally considered and
iscussed in this report, since during the time of its maturity the cli-
ıatic conditions are very similar to those existing everywhere in the
rid regions of the United States. Two crops are annually grown in
ndia, one of which is sown in early spring at the beginning of the
ıonsoon or rainy season, and is called the summer or kharif crop.

This crop depends little on irrigation for its maturing, as the gr proportion of the rain of the entire year falls during the summer the autumn, however, the rainfall is very light, and, as before st the temperature and precipitation are both similar to those in West.

Though the conditions of government and people are so differ India from those in America, many useful examples and lessons m drawn from the method of administration and legislation practiced as well as from the financial success or failure that has attende construction of their works. The conditions under which Amer must undertake irrigation enterprises are not so different from existing in India and southern Europe as would at first appear. works we may construct must depend for their utilization and re on immigration, as they will be largely in a sparsely inhabited co In order to induce this immigration people must be convinced of benefits and utility of irrigation. Conditions similar to these in portions of India where the most successful irrigation pr have been carried out. Irrigation works have frequently been u taken in portions of India that were already overpopulated. T have rendered the land more fertile and sufficiently productive to port nearly double the population which it was previously capa sustaining. This, too, has been accomplished despite the prejud be overcome, and the difficulties encountered in inducing people to use of the water furnished; difficulties far greater than we would to contend with in inducing immigration to our arid West. A the great canals of the Northwest Provinces and the Punjab undertaken in districts that were sparsely inhabited. These ca are among those of India that have paid the largest interest o original outlay. Within ten years from their construction the co was fully populated, although the immigration was often from r portions of India.

Any imperfections which may appear in this account of work amined and in operation are in no way due to lack of assistance the engineers in authority. It is impossible to speak strongly en of the hospitality and kindness with which I was everywhere tr In fact, owing to the limited time at my disposal, the greates culty experienced was to leave the hospitable guides and entertai who were apparently willing to spend days in showing and expla the works they had in charge.

PREFACE TO SECOND EDITION.

This account of some of the more important irrigation works of ndia was first published in Part II of the Twelfth Annual Report of he Director of the United States Geological Survey, for 1890–91. The emands for this report were so great that the entire edition was xhausted within a few years. Recently, and largely as a result of he renewed activity in irrigation in the Western States through the reation by Congress of the Reclamation Service of the United States Geological Survey, there have been increased calls for this report. At the instance of Mr. F. H. Newell, chief engineer of the Reclamation Service, I have made a careful revision of this report from such available data as I have succeeded in accumulating during the intervening years. This edition is published as one of the series of Water-Supply and Irrigation Papers of the Geological Survey.

Comparatively few new works have been built in India since 1890. The Bhatgur and Tansa dams have been finished and are in successful operation with but slight modifications from the plans as previously published. The great Peryiar project has been completed with slight modifications. These changes are noted in the accompanying text. In addition, the matter concerning inundation canals and that descriptive of deltaic canals have been extended. Under the latter head the Kistna project is described in more detail, as is the Sangamanicut project, both of which contain works which will interest American engineers. Under title of "Tanks" the Rushikulya project is described, both because of the interest attached to the dam and because it is a combined project including the diversion of water from a running stream and its storage in a reservoir located at a considerable distance from the canal head.

The most important feature of the revision is the bringing of all the financial and statistical data concerning the more important works in each province up to 1901, the date of the last official Indian reports. At the close of 1901 the area of India, including native States, was 1,559,603 square miles, the total population was 294,266,701, and the total expenditure upon all classes of irrigation works by the Government of India had been $337,850,000. In the year 1900–1901 the expenditures on account of irrigation amounted to $11,500,000 and the revenues to $12,075,000, showing a profit of 7.5 per cent on the capital outlay for construction. The total area cultivated in India the same

year was 180,151,093 acres, and the total area irrigated was 18,611 acres, or, counting areas double cropped or those irrigated more than once in a season, the area irrigated was 33,096,031 acres. The estimated value of the irrigated crops in 1900–1901 was $150,000,000. Of these it is interesting to note that the area under cultivation to wheat amounted to over 16 million acres, and in cotton to over million acres, and that the total value of the latter crop alone was $52,773,000.

Construction, including in large measure repairs, was most active during the past few years, in order to afford employment in famine stricken regions. The demands on the water stored in reservoirs in the semihumid portions of India—those which had been afflicted with drought and consequent famine during the last few years—were greater than ever before. Some of the more notable tanks in Bombay and central India were called upon to do their highest duty, and in consequence many of those projects which were constructed as protective works and were never anticipated to be revenue producers have recently earned moderate net revenues.

H. M. W.

WASHINGTON, D. C., *December 22, 1902.*

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IRRIGATION IN INDIA.

By HERBERT M. WILSON.

INTRODUCTION.

The principal sources from which the information in the accompany-
g report was obtained were (1) conversation with engineers in charge
works and examination of their office material, (2) personal exam-
ation of the works themselves, and (3) books and official reports.
the following narrative I will endeavor to sketch hastily the route
aveled and give a brief outline of works visited.

For a week before my departure I was busily engaged in reading all
e books and reports on Indian irrigation procurable, in order to plan
e trip so as to see the most in the least space of time, for I had but
/e months for the entire journey. I finally decided that the two
onths spent in India should be devoted to the northern and central
ortions, and the route was planned so as to see only such works as
ere within easy access of the railway lines.

Through the cooperation of the director of the United States Geo-
gical Survey I was enabled to leave Washington on December 1,
889, well equipped with letters of introduction to the various secre-
ries of the public works departments of India, carrying also letters
om the Secretary of State to our diplomatic and consular officers
broad. In New York letters of introduction to prominent English
igineers were obtained from the secretary of the American Society of
ivil Engineers and others, and on December 4 I sailed for Liverpool.

A few days were spent in London, where, through the courtesy of
[r. James Forrest, secretary of the Institution of Civil Engineers, a
umber of letters of introduction to Indian officials were obtained.
rom London I proceeded to Brindisi, Italy, and embarked December
) for Bombay, arriving there on January 13, 1890.

In Bombay I called upon Mr. W. C. Hughes, secretary to govern-
ent for the irrigation branch of the public works department, and
e gave me letters to several of the engineers in the Bombay Presi-
ency, and kindly aided me in so arranging my tour in that presi-
ency as to see only such works as were most accessible. From Mr.
V. Clerke, chief engineer of the Bombay waterworks, I also received
uch valuable assistance and advice, and on January 18 I proceeded

to Poona with the intention of visiting the Fife reservoir. In absence of the chief engineer, Colonel Cruikshank, R. E., Mr. Rels executive engineer of the Mutha canals, devoted two or three days showing me over the works under his charge.

We drove from Poona to Lake Fife, a distance of 12 miles up valley of the Mutha River. The road here, as everywhere in India was excellent, being well macadamized for the entire distance. both sides were well-cultivated fields, the principal crops grown be sugar cane, millet, and wheat, and the care with which the water applied to these crops was the first object which attracted attention I also observed that Indian peasants fully appreciated the value fertilizers. The city officials of Poona make a handsome profit annually by removing excrement from the residences and mixing it ordinary soil, the whole being sold by the cartload to farmers.

Lake Fife is a large artificial reservoir, formed by a dam three quarters of a mile long and nearly 100 feet in height. The water backed up the valley for nearly 15 miles, and the available storage capacity of the lake is about 63,000 acre-feet. The Mutha canals are taken from the dam at the lower end of the lake, one along the right and the other on the left bank of the Mutha River. The right-bank canal is nearly 100 miles long and passes through the city of Poona which it supplies with water; it is also used in irrigating the rich land lying between it and the river. The left-bank canal is much shorter and also controls a large area of valuable land.

The topography of the Upper Mutha Valley seemed very familiar. Had I been suddenly transported in my sleep to northeastern Arizona the similarity of the topography of the two regions could not have more strikingly impressed me. At Lake Fife the Mutha River makes its exit through a narrow canyon similar to those of the mesa country in northern New Mexico and Arizona, and flows thence through a broad and gently sloping valley, which gradually widens till it becomes an extensive plain. The slope from the bottom of the stream towards the surrounding hills is regular, but rather steep, and suddenly terminates at the foot of cliffs which are similar in their abruptness and sharpness of outline to the mesa cliffs of our Southwest. The soil in the Mutha Valley is rather shallow, and wherever uncultivated is covered with a low, scrubby grass, dried and parched by the sun. At the canal edge the barren slopes are suddenly merged into endless green and well-cultivated fields. The slopes of the hills are rocky and barren, covered with a growth of low trees, among which babul or mesquite is the most prominent.

After examining Lake Fife, Mr. Rebsch and myself proceeded down the line of the Mutha canal and followed some of the minor distributaries through the fields, watching their ramifications, until we reached the smallest private ditch used in irrigating the crops. The construction of these canals is similar to that of small canals in the United

tes. The chief feature noticed was the substantial method of con-
ıcting all bridges, head-gates, and other regulators. Here, as else-
ɔre in India, timber is seldom used, owing to its cost and the rapidity
h which it is destroyed by insects and rot. All bridges on this canal
constructed of masonry, and the smallest regulating gates consist
nasonry passages let into the banks of the canal and closed with iron
tters. The system of distribution of the water is very complete
ry square foot of desirable land being under cultivation.

ɔn January 21 I engaged a tonga, a sort of dogcart, drawn by a team
ɔonies, in which a three days' trip to Bhatgur reservoir and the Nira
ıals was made. The trip to Bhatgur was made in the night in order
ıvoid the heat. The road is macadamized the entire distance, and
ined on each side with a double row of trees, which furnish a dense
l agreeable shade. The gradients are sufficiently easy for a rail-
y, while all drainage passages, large or small, are crossed by masonry
dges. In order to avoid excessive grades a range of low hills about
lfway in the journey is pierced by a tunnel nearly one-fourth of a
le long. This tunnel is about 20 by 20 feet in cross section, and is
ed with masonry throughout.

At Bhatgur I was met by Mr. H. Beale, assistant engineer in charge
construction of the dam. During the day we went over the entire
ıgth of the dam and viewed all the works of construction. It was
/ good fortune to see the Bhatgur dam when it was about two-thirds
mpleted and while the construction was being vigorously pushed. I
ıs thus enabled to examine with care the details not only of the
ɔthod of masonry construction, but also the management and char-
ter of the labor employed.

The topography above the Bhatgur dam is very similar to that at
ıke Fife. The dam is constructed on a modern cross section, similar
that obtained by the Bouvier or the Rankine formula. It is located
a rather wide part of the river, the object being to afford sufficient
ıillway for the large volume of water which comes down the river in
.e spring floods. Its length is 4,067 feet and its greatest height is
0 feet above the foundations. The river at this point is subject to
aximum floods of 50,000 second-feet. This reservoir is used as a
orage basin to supply the Nira canals, which are taken from the Nira
iver at Vir, a point 20 miles below the dam. During my visit to
hatgur 1,500 laborers were employed on the work and completed
bout 5,000 cubic feet of rubble and concrete masonry per day and
000 cubic feet of finished dressed-rubble facing. Stone for the con-
ıruction of the dam was quarried close to the abutments, and kunkar,
dirty lime which produces a very good hydraulic cement, was found
ithin a short distance of the dam site. Sand was procured from the
iver bed and charcoal for burning was obtained in the adjacent hills.

On the morning of the 22d I left Bhatgar, proceeding by tonga to Vir,
he head of the Nira canal, where I was met by Mr. W. H. Le Quesne,

executive engineer in charge of the Nira system. The next two d were spent in looking over the reports and detailed maps in the o in examining the great diversion weir at the head of the Nira ca and inspecting the first 12 miles of the latter. The Vir weir is c structed throughout of concrete, faced with dressed-rubble masc and is 2,340 feet in length and 40 feet in greatest height above river bed. A few hundred yards downstream is a subsidiary w similar in construction to the first, but only 615 feet long and 20 in height. This lower weir backs the water up against the toe of upper one, thus producing a water cushion, on which the great fl fall harmlessly. The maximum flood over this weir may be 1 second-feet, when the water will be about 8 feet in depth on the c of the main weir. Our trip down the canal was made in a row and we were thus enabled to examine several aqueducts and a sip on the way. The first 10 miles of the canal are for diversion line being required in making grade to get the canal out of the confl banks of the Nira River. At about the tenth mile the first distr tary is taken off to the irrigable lands.

On January 23 I left Vir for Lonand, where I took the train Poona. This trip is one of the most interesting in India, the passing through the celebrated Bhore Ghauts, a range of rugged, hills which break down precipitately to the western ocean. The s mit of these Ghauts forms the edge and top of the great interior teau of the Deccan. The scenery along the entire descent is sim in every respect to that east of the line of the Southern Pacific R road near Red Bluff. The road runs with heavy grades and sh curves along the edges of nearly vertical trap cliffs, in a place th almost any other country would be considered quite impracticab railway construction. The expense of such a line in the United St would exceed $100,000 per mile. Owing to the very heavy rain which averages 250 inches per annum, the greatest precautions h been taken for the passage of all drainage lines. Numerous viad are crossed in rapid succession, the frequency of their recurr being rivaled only by that of the many tunnels, there being 33 of th in a few miles.

I had been very desirous of making a visit to the celebrated Ta reservoir, near Bombay, in the company of Mr. Clerke, the chief e neer, and on arriving in Bombay, on the 24th, I found he had arran a trip with the governor of Bombay, Lord Reay, a few of the munic officers, the governor's staff, Mr. Baldwin Latham, and myself. W left by special train on the evening of the 24th, arriving at Atgoa the following morning. From Atgoan we had a pleasant tonga of 7 miles to the site of the Tansa dam. Here I was as fortunate at Bhatgur. I found the great dam more than half completed a construction being vigorously pushed. Two days were spent inspecting the works, which consist mainly of an enormous rubb

sonry dam 9,350 feet in length. When completed it will be 145 t in maximum height. This dam is intended to furnish water for city of Bombay. The rock for its construction is quarried at the n site, but kunkar, for the production of cement, has to be brought g distances by rail or road cart. The aqueduct line, which carries water to the city of Bombay, is partly in tunnel, partly in masonry nduit, partly in iron pipes. It has seven inverted siphons crossing ainage valleys, the greatest being 11½ miles in length.

On January 28 I left Bombay for Calcutta, a distance of about 1,200 les. This trip was full of interest. During the early part of the st day the Thule Ghauts were ascended, the difficulties of construc- n being quite equal to those on the line between Poona and Bombay. ilway travel in India, while inferior in comforts to the United States, still decidedly superior to European modes of making lengthy trips. e cars, like those on European railways, are short, and on only a w are bogie trucks used. These latter, however, are rapidly find- g favor, and at no distant day will be universally employed on the dian railways. Each compartment, of which there are two in every st and second class carriage, will hold from five to six persons. The ats are placed lengthwise of the train and are well cushioned. here is a hanging seat or bed suspended from the roof, similar to ose seen in an American immigrant car. This can be lowered at ight and used as a berth. Each passenger must carry his own edding, which in that warm climate consists of nothing more than a lanket and a pillow, and spreading these on the seats or hanging eds he can pass a comfortable night on the road. In the center of e car, between the two compartments, is a small closet and toilet om. A table may be set up in the center of each compartment on hich to spread lunches. Men and women are never permitted to avel in the same compartment. Good meal stations are placed at onvenient intervals on all lines of railway, and ample time is given or eating.

The main portion of central India lying between Bombay and the angetan Plain is rather sparsely inhabited. The region is elevated nd consists of uneven, rolling country, similar to that along the outhern New Jersey coast or in the wooded districts of Missouri and ndiana. A dense growth of jungle, consisting of low trees, mesquite, eak, etc., with an undergrowth of tall, stiff jungle grass from 5 to 10 eet in height, covers the entire country. The streams draining this rea are, during the dry season, but little rills, flowing through very road, wide, sandy beds, that serve to indicate the enormous size these ivers attain during the flood season. There is little irrigation prac- iced in this region. In some sections moderate areas are irrigated from anks of various sizes. The sloping hillsides are terraced, like those of Japan and China, by the construction of embankments. These produce level benches, where the flood water is held back sufficiently

long to enable it to soak into the ground. On these benches su crops of rice, garden truck, and grain are cultivated.

The River Jumna is first crossed and the Gangetan Plain enter Allahabad, between which place and Calcutta the country is extren level and fertile, having a strong resemblance to the broad, le prairies of the Mississippi Valley. Throughout this portion of route fine fields of wheat, millet, barley, indigo, cotton, sugar ca and poppy were passed in endless succession, while occasional gro of mangoes, cocoanut, and date palms relieve the prairie-like appe ance of the country. The entire region is divided into innumera small fields, each of a few acres, but no fences or houses were to seen, though laborers dotted the fields. All live in villages, fr which the laborers sometimes travel several miles to work.

I arrived in Calcutta on the morning of January 30, and called Dr. W. King, the director of the geological survey of India, who g me letters of introduction to some of the officials I was desirous of me ing. Mr. B. F. Bonham, American consul-general, treated me wi the utmost courtesy and did everything in his power to aid me durin my short stay. One day was spent at the office of the surveyor-gener of India, Col. H. R. Thuillier, R. E., who kindly aided me in th examination of the methods of work of the topographic division a of the great trigonometric survey.

On the 31st I called on Col. J. M. McNeill, R. E., the secretary f government of the public works department of Bengal. With him discussed the arrangement of my tour through his presidency, a from him I received letters of introduction to his various executiv engineers. Colonel McNeill kindly telegraphed to Mr. R. B. Buckley, superintending engineer of the Soane canals, to arrange a hasty tri over his territory, and on the following day I reached Arrah, when I called upon Mr. Buckley. That day was spent in examining the map and office records of the Soane canals, and on the following morning I set out on a tour of inspection. Mr. Buckley kindly placed at my disposal his canal steamer *Kudra*, on which I lived for three days, a Mr. Buckley also telephoned over the canal lines, arranging for va ous engineers to meet me and show me various points of interest.

I started early in the morning of February 2, and steamed up th canal against the current at the rate of about 8 miles an hour. Th rate of travel was rather slow, owing to the velocity of the strea and to the great number of locks which had to be passed. At Arra the canal is 86 feet wide at bottom, about 9 feet deep, and discharg about 2,000 second-feet of water. From there to the headwaters a Dehree, a distance of 65 miles, the Arrah branch follows the gener direction of the Soane River on its western side, gradually increasin in width toward the head, where it is 180 feet wide at bottom, 9 fe deep, and discharges about 4,300 second-feet.

As Nasregunge, a large village midway between Arrah and Dehre

vas met by Mr. Inglis, the executive engineer of the Arrah canal, o showed me the heads of some of the distributaries, the escapes, d also the mode of applying the water to the fields. I reached hree at 8 o'clock on the following morning. During the absence the executive engineer in charge of the head works at Dehree, I s met by Mr. Williamson, the overseer of the shops at that point, o spent the day explaining the various works. These are of the st interesting and important nature, and consist of the great weir ross the Soane River, 2¾ miles long and 14 feet in height, of the uring sluices and regulators at the heads of the canals at each end, d of the general machine shops for the construction and repair of gines, dredges, and other metal works used on the canal system. e Soane River was then very low, scarcely discharging more water an was required to fill the main eastern and western canals. anks to this fact, I was enabled to watch the operations of the auto-atic sluice gates, which were lowered and raised for my inspection. From Dehree I proceeded again by steamer down the Buxar branch the main western canal, passing through immense fields of grains d vegetables, where but a few years before had been but a desert aste. One work of particular note passed was the Kao Nulla siphon queduct, whereby the canal is carried over the bed of the Kao Tor-nt and the latter in a semisiphon is passed under the aqueduct. A ttle farther on was a similar work by which the canal is carried in n aqueduct over the Thora Nulla. In the evening I arrived at the wn of Buxar, where I met Mr. Horn, the executive engineer of the uxar branch, and left the same night for Allahabad.

During the trip along the Soane canals many interesting scenes ere noticed. Numerous canal boats loaded with grain or stone were assed. These were being taken to the railway or floated out on the anges River, whence they made the trip to Calcutta. The boats are eculiarly shaped, being higher at the stern than at the bow, varying rom 15 to 25 feet in length, and having a width of about 10 feet. In he center is erected a pole, perhaps 12 feet in height, to which are ttached numerous light strings, and each of these is drawn by a ative on the towpath. On these canals it is not unusual to see ten or nore men towing one boat.

The important roads cross the canal by means of well-constructed nasonry or iron bridges. A peculiar accident has occurred to many f the masonry bridges, as the pressure of the earth embankments ehind the abutments causes them to act as retaining walls. The ressure has in several cases caused the arches to spring upward at the center or key, leaving a slight crack on top. These bridges have been constructed strong enough to perform their duties as bridges, but are not sufficiently strong to act as retaining walls.

The smaller roads and footpaths terminate at the canal banks, where catamaran-shaped ferryboats are used to cross the canal. These

boats are unique in construction. Each pontoon is composed of riv sheet iron and is 2 feet wide by 2 feet deep and 15 feet in le Between the two is supported a wooden deck 6 feet wide, sufficie large to carry the ordinary two-wheeled bullock cart with its te A chain is laid from one bank of the canal to the other, long eno to rest on the bottom of the canal, so as not to impede traffic, and pa ing through a ring on the deck of the ferryboat. By pulling on chain the occupants are enabled to draw the boat across the cana

The canal banks are lined throughout with plantations of trees property of the canal government. These are cut and sold as m seem desirable to the canal officers, all trees thus removed be replaced by young growths. Among the more usual trees are sissoo, somewhat like the teak in general character, and used in construction of furniture, carts, etc., the sal, also used for furnit and fuel, some mangoes, and some mesquite.

Owing to the low velocity, about 3 feet per second, which it is necessary to give the navigable branches, considerable deposits of accumulate near their heads, and lower down, where the water clearer, reeds and rushes line the banks well out toward the middle the stream. Large steam dredges are kept at work on the upper of the Soane canals, giving them much the appearance of the S Canal. These dredges have mostly been constructed at the shops Dehree, and are of iron throughout, as are also the scows. La steam passenger boats ply on the main canals, stopping at the vari villages lining their banks and terminating their runs at the railwa These boats are crowded with people, which indicates a profita passenger traffic.

Among the most interesting scenes observed were the enorm crowds of pilgrims, afoot, on camels, or on bullocks. These pilgri make journeys between distant shrines, often occupying six mon in the longer trips. Each devotee carries a pole across his back, fr the ends of which are swung the few necessaries of food and clothi

The locks along the canal are substantially constructed of br masonry, sometimes singly and sometimes in pairs, and average their lift from 7 to 12 feet. These locks are sufficiently long and w to accommodate the big passenger steamers. Beside and around th locks is always constructed a waste weir and channel through wh the greater part of the discharge of the canal used in irrigation a not required in operating the lock is passed. In this channel is n essarily a high fall with a drop equal to that of the lock. This is built of the most substantial masonry in order to withstand the caused by the great body of water passing over it.

On February 5 I arrived at Allahabad, the capital of the Northwe Provinces and Oudh, where, during the absence of the chief engine and secretary for government, Col. G. T. Skipworth, R. E., I was ve courteously treated by Mr. H. W. Conduitt, the office assistant. E

ve me some official reports and letters to engineers in the northwest d arranged for a visit to the Betwa, Ganges, and other canals by iting to the executive engineers in charge, informing them of my proaching visit and requesting them to render such assistance as ght be required. On the same day I proceeded to Orai, where I s met by Mr. W. P. Vonder Horst, the executive engineer of the twa canal. The 6th was spent in examining the office records and ps and making such notes and tracings as were deemed necessary. the same evening we left by rail for Chirgaon, whence a short tonga le took us to Paricha, the head of the Betwa canal and the great twa reservoir.

The Betwa reservoir is constructed in the channel of the Betwa ver where it emerges from the Northern Ghauts. The weir is ated in a rather wide part of the river bed, crossing the stream in an egular line, abutting in one place on a large island and at another a broad rock in the middle of the river. The total length of this ir, including the islands on which it abuts, is about 4,300 feet, and greatest height in the middle of the channel is 60 feet. The entire m acts as an overflow weir, in order to give sufficient wasteway to e enormous flood of 750,000 second-feet which may pass over it. ch a flood would bank 17 feet deep over the crest of the weir. In der to withstand the shock of this body of falling water two small bsidiary weirs have been constructed in the channel below the epest portions of the weir, thus giving a water cushion on which e maximum height of the overfall is 21½ feet. The net storage pacity of this reservoir available for irrigation purposes is nearly ,000 acre-feet.

The canal system heading immediately above the dam controls an ea of about 950,000 acres, of which about 400,000 is excellent arable nd. The balance is very poor and barren. This area of irrigable nd is included between the Betwa, Pahug, and Jumna rivers, and at esent about 135,000 acres are irrigated by the canal system. The shing sluices on the end of the weir adjacent to the canal head and e regulators at the canal head are of great interest, owing to the essure of nearly 60 feet under which the gates are operated.

From Paricha I proceeded by rail to Agra, and on February 9 went Narora, where are located the head works of the Lower Ganges canal. order to reach Narora it was necessary to go by rail to Aligarh, here a couple of hours were agreeably spent. From Aligarh I went y rail to Rajghat, which station was reached late in the evening. here, thanks to the thoughtfulness of Mr. E. A. Carswell, the execu- ve engineer in charge of the Narora works, I was met by a hand car r trolley, in which I was pushed by natives 5 miles to the bungalow t Narora, where the following night and day were spent. I was ceived by Mr. Carswell with the same hospitality that had been ccorded me by all the other officials with whom I had come in con-

tact. The larger part of that evening and the next day were sp in examining the office reports and maps and examining the h works and the river training system of the Lower Ganges ca These head-works consist of a great weir 4,135 feet in total len 3,700 feet of which are composed of an overfall weir 14 feet in hei above the foundation, 315 feet consisting of sluice gates adjacen the head of the canal. The head of the canal adjacent to the en the weir consisted of 26 regulating gates, each 7½ by 11½ feet in clear. The maximum flood coming down the Ganges which may p over this weir may be as great as 230,000 second-feet.

The river training works are interesting and extensive. They necessitated by the low character of the river bottom, in which canal is constructed for some miles before its diversion line gets o the bottom and reaches the summit of the bluff. Where these bo lands are traversed the river is apt to change its channel, and if controlled would cut its banks, thus destroying the canal. The re lating works are carried for 4 miles above the head of the canal a 15 miles below it, and consist of long earthen embankments or groy which jut straight out into the river channel at right angles to course and are protected on their ends by rock paving and rock ma Sixteen miles below the Narora weir the Lower Ganges canal cro the great Kali Nadi Torrent, which in time of floods becomes an e mous river. The canal is carried across this torrent on an aque which provides water way for a flood of 130,000 second-feet. T channel of the canal on the top of the aqueduct is 130 feet wide a 7 feet deep. Previous to 1885 there was in this place a short aque calculated to pass a flood of 30,000 second-feet; but in that year it w destroyed by an unprecedented flood of nearly 130,000 second-f and has since been entirely remodeled and reconstructed.

On February 12 I left Narora for Lahore, the capital of the provi of Punjab. In the absence of Col. F. J. Home, R. E., the chief en neer for irrigation in the Punjab, I presented my letters of introd tion to Mr Cockhorn, the office assistant, who had been instructed Colonel Home, in anticipation of my arrival, to furnish what aid could. In the Punjab I was less fortunate than elsewhere. T works of that region are among the greatest and most interesting India. I reached there in the midst of the busiest part of the f season. Most of the engineers were far out of reach of railways other convenient modes of travel, in charge of the construction works, and as time was limited it was impossible to go far out of t way to meet them. Accordingly, I decided not to visit the works the Western Jumna nor the Bari Doab canals, but to devote t remaining time to a thorough inspection of the Sirhind canals, wh are the most modern and perhaps the most interesting of any of t canals of India.

I at once proceeded to Amrister in hope of meeting Major Ott

E., the supervising engineer, from whom I expected information d assistance in the trip. Here, again, I was disappointed, and found one who could give assistance or advice as how to visit them best. ccordingly I decided to go to Ludhiana, the nearest railway point to e canal. I reached there on February 14 and called on Mr. J. mpster, executive engineer in charge of the Sirhind canals. I did t receive much encouragement from Mr. Dempster, as he said that ing to not having been previously advised of the trip and the shortss of the time it would be nearly impossible to arrange conveniently show me the canals. From Ludhiana to Rupar, where the headorks of the canal are, is a distance of about 60 miles, and to make is trip it would be necessary to engage an elephant and to procure e necessary traveling outfit. As I did not know where to find these, d Mr. Dempster was apparently too busy to aid in the search, I luctantly abandoned the journey, and on the same day left by train visit the Ganges canal.

Next morning, February 15, I reached Roorkee, where I found that r. M. King, executive engineer, had made elaborate preparations for e trip over the line of the canal. I also found Col. G. T. Skipworth, . E., chief engineer of the Northwest Provinces and secretary to vernment, and Mr. W. J. Wilson, his assistant secretary. They had ade preparations for the annual inspection of the lines of the canal, ut as they would not be prepared to set out on their trip for a few ays, Mr. King had arranged to take me to the head-works and return Roorkee in time to accompany the inspecting party. A portion of e 15th was spent in examining the office records and maps, and early n the following morning Mr. King and I set out on a tonga drive long the banks of the canal bound for Hardwar, where are situated he head-works. Owing to the heat, though the distance was but 20 iles, two relays of horses had been sent out to hasten the journey. wo heavy bullock carts laden with camp equipage, etc., and an elehant which would be required in making journeys away from beaten oads, had also been previously forwarded to Hardwar. In the course f the drive along the canal banks we had an excellent opportunity or investigating the level crossing of the Rutmoo Torrent at Dhanowri. We also examined the great aqueduct by which the Ganges canal is arried across the Solani Valley and the superpassages which conduct he waters of the Puthri and Ranipur torrents over the Ganges canal. These works were also examined on the return trip to Roorkee, when was enabled to observe other points of interest that had escaped notice on the first inspection.

We spent the night at Hardwar and on the following day set out on he elephant to examine the various river training and regulating works, whereby the greater part of the water of the Ganges River is guided into the Hardwar channel, from which it is diverted into the canal. These training and regulating works extend for a distance of

several miles above Hardwar and are unique from the fact that supply of water being at all times abundant for the demands of canal, no permanent dam has been thrown across the river. The of the river is here broken up into several channels and is very w but by means of a row of three temporary dams constructed of b ders the majority of the water is turned into the Hardwar chan These temporary dams, it has been found, can be more cheaply re structed annually after their destruction by the regular floods, th great permanent weir could be built across the entire channel. Al the temporary bowlder dams a permanent masonry wall has been structed on one minor channel besides a series of permanent bow embankments and bars, the latter to prevent the retrogression grades. Groins and other training works so confine the main b of water to the Hardwar channel that during times of greatest fl when all of these works are submerged, little or no damage is don the permanency of this channel. At Myapur, the head of the Ga canal, below the training works, a permanent weir with the u scouring sluices has been thrown across the Hardwar channel. training the water into the regulator at the head of the canal.

On the following morning we continued our inspection of the h works and in the afternoon returned to Roorkee. The 18th was sp at Roorkee in a visit to the Thomason College of Civil Enginee where Colonel Brandreth, the president, kindly showed me over building and furnished numerous valuable reports and other in mation.

On February 20 I reached Okhla, near Delhi, at which place situated the head-works of the Agra canal. Here, thanks to the k ness of Colonel Crofton, superintending engineer, who had wr from Roorkee of the intended visit, I was met by Mr. C. G. Pal the executive engineer of the Agra canal, with whom I visited works under his charge. The head-works of this canal consist low weir 10 feet in height and 2,573 feet in length from the right ba the left wing resting on an island in the middle of the river. Wi and heavy earth embankments, 20 feet wide on top, are carried ac the island and the east channel and thence up the left bank to railway bridge at Delhi.

This canal receives its water supply from the Jumna River, wh however, does not at all times carry sufficient water to fill it. supply is accordingly augmented by means of a cut from the Hin River, which empties the water of that stream into the Jumna al the diversion weir. In the weir there is the usual set of scour sluices at the end adjacent to the canal head and the customary re lating gates and lock for navigation purposes at the canal entran Like the Ganges River at Narora, the Jumna here requires the c struction of great river training works similar in their general ch acter to those on the Lower Ganges, but in order to throw the gre

ADEN TANKS, ARABIA.

ɔrtion of the water toward the right bank of the river, where the anal head is, alligator groins have been run at right angles to the ne of the weir, by means of which the water is trained in the desired irection.

After examining the office records and maps at Okhla, Mr. Palmer nd I made a trip by tonga down the line of the canal to examine some f the works of interest. We passed several inlets by which the drainge of small streams heading in the hills to the south is admitted to ıe canal. The water enters by stone culverts, and the core of the anal embankment at these places is usually constructed of rubble ıasonry. These inlets are generally controlled from a gate tower. Near the Ali Torrent the canal banks are protected on the upper side y a long earthen dam, forming a storage reservoir which catches the rainage of several small streams from the hills and passes this through n outlet or spillway into a superpassage of sheet iron carried over the anal. The water retained in the reservoir is allowed to settle, and vhen clear of silt is admitted into the canal, but in time of floods the uperabundant discharge is carried over the spillway previously menioned and discharged into the Jumna. Many hundreds of small tanks ıave been constructed all through this region, and one very large one s now under construction on the Surwa River about 15 miles above Baroda.

Among the most interesting sights from a scientific point of view to ɔe seen in India are the ancient astronomical observatories erected by he old Arab astronomers at Delhi and Jeypur. At the latter place I ıad an opportunity to examine carefully the observatory of the Shah Jehan, which covers a couple of acres of ground and is surrounded by ı high stone wall. Within this inclosure are constructed many unique masonry instruments with which were conducted the observations of the ancient astronomer.

On March 3 I reached Bombay, and a few days afterwards left for home.

At Aden I stopped a day, thus giving sufficient time to examine the strange old reservoirs (Pl. II), constructed in a gully above that town, which supply it with water. It is only once in several years that a sufficient rainfall occurs in this arid region to fill the tanks. There are several of them, one above the other far up the gully, and it was my good fortune to be there a few days after the occurrence of the first storm that had filled them in three years. They are most carefully constructed, lined throughout with hydraulic cement, thus preventing any leakage through their rock bottoms, and are closed by substantial dams with wasteways and masonry conduits leading from one to the other, so that the least possible amount of water will be lost by absorption. The total storage capacity of these tanks is about 12,000,000 gallons.

From Aden I proceeded direct to Suez, where I took the train for

Cairo, arriving there on March 18. Here I called upon the Ameri consul-general, Mr. Eugene Schuyler, who informed me how best see the irrigation works in the immediate vicinity. By him I w introduced to Col. Sir Scott Moncrieff, the minister of public wo for the government of Egypt, from whom valuable information numerous reports relative to the irrigation works of that coun were obtained. The next day the Barrage du Nil was visited, it be readily reached by a railway trip from Cairo occupying about an ho Two other trips to the Barrage were made, during which ample opp tunity was had to examine the works. Construction was be rapidly pushed, and there were probably 6,000 workmen emplo on them.

A few days later I proceeded to Brindisi, Italy, thence to Ro where I arrived March 30. In Rome, thanks to the kindness of American minister, the Hon. A. G. Porter, I called upon the mini of finance, under whose direction are the irrigation works of Ita From him I received a letter to Signor Carlo Sospizio, the director the Cavour canal at Turin, and on the following day I reached Tur Signor Sospizio was very courteous, and arranged to have one of subengineers meet me the following day at Chivasso, where the h works of the Cavour canal are, and show me over them.

On April 2 I was met at Chivasso by Signor Canavotte Oreste, assistant engineer. With him the following two days were spe an inspection of the line of the Cavour canal as far as the inve siphon crossing the River Sesia. The trip was made from Chiva in a carriage along the canal banks as far as the aqueduct cross the River Dora Baltea, below Saluggia. From this point the carri was sent around the road to Saluggia and we examined the canal a aqueduct on foot, rejoining the carriage at Saluggia.

The weir across the River Po at the head of the Cavour canal temporary one, constructed of brush and rocks, and is not over 5 f in height. This weir has to be annually repaired, but this is le expensive than the construction of a permanent one would be. W the River Po is low, and does not discharge sufficient water for wants of the canal, additional water is supplied by the subsidi Canal Farini, while the Canal Rotto adds some of the water of Dora Baltea to it.

Above Saluggia, near Cigliano, is an interesting arrangement lifting the water from a low- to a high-level canal. This consists four levels of canals. Between the two lower ones is placed an ex sive pumping plant, operated by turbines which receive their wa from the upper of the two lower canals and tail into the lower ca whence the water is distributed to low-lying fields. The lower of two upper canals supplies water by means of an immense wrou iron pipe, 3 feet in diameter, with a head of about 66 feet, to

ımps below, and these force it, through another pipe of the same mensions, a total height of 140 feet, to the high-level canal, whence is distributed to the upper fields.

From Saluggia we proceeded by rail to Santhia, near where the ınal Cigliano passes over the Ivrea canal and at the same time supies it with water. The night was spent in Vercelli, and in the ɔrning we proceeded to Greggio, where the Cavour canal passes ıder the River Sesia in a great siphon nearly 800 feet in length, hich carries the entire capacity of the canal. This system consists four channels or conduits constructed of masonry, oval in shape, e inside diameters of which are 9 by 15 feet.

On the following day I proceeded to Milan, thence over the cele-ated St. Gotthard route through Switzerland to Paris, where I arrived ı April 6. In Paris, through the courtesy of the minister of public orks, I received a letter to M. Caméré, engineer in chief of bridges ıd roads, located at Vernon, with whom I examined the various ırrages which regulate the navigation of the Seine. At Paris the ıamination of irrigation works came to an end, and I proceeded ıence direct to the United States.

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CHAPTER I.

FINANCE AND STATISTICS.

VALUE AND NECESSITY OF IRRIGATION.

In view of the interest in the subject of irrigation which has been cently developed in this country, it will be well to observe what enefits have been derived financially and otherwise from the irrigation orks that have been in active operation in India during the last century, and also to note what Indian and English statesmen and engineers have to say on the subject of the extension of irrigation in India. ecause of the similarities of the countries, climates, and the conditions under which irrigation works are operated in America and ndia, some useful lessons may be drawn from these comparisons. It as already been shown that the conditions of the utilization of the aters of irrigation works are quite similar in the two countries, and at the autumn crop in India is cultivated under circumstances lmost identical with those under which our ordinary summer crops re grown in the arid regions.

The Indian financier divides the irrigation works into two great lasses, called major and minor works. Major works are generally ose of more importance from an engineering point of view, and have een in some cases almost entirely constructed by the British Government, while the minor works are of smaller pretensions and in many ases modifications or improvements of existing ancient irrigation ystems. The portion of the major works that are constructed from apital provided from the general revenues of India are styled "protective works." "Productive works" are usually constructed from apital which has been borrowed, and it is expected that a sufficient rofit will be realized from their operation to pay interest on the borowed money. Many minor works are also productive works. In eneral, protective works are constructed as a protection against amines, and they act in the amelioration of these in two ways. First, hey are constructed during famine times to give employment to the eople and furnish them money and food for their sustenance, and econd, after their construction they are expected to furnish sufficient vater for irrigation purposes to render them a protection against uture droughts and the resulting famines. The majority of these amine protective works consist of storage reservoirs constructed in he more arid portions of India.

The reason for the success of the greater productive works of nor ern India is twofold. First, these works are constructed in a coun similar to that of the western United States, so barren and devoid water that nobody could live there or produce crops of any sort u canals had been dug and water provided for irrigation. Accordin all those who immigrated to the neighborhood of these canals wer once compelled to use and pay for the water, otherwise they w have been unable to raise crops. It is owing to the fact that th works have been able to do their full duty and the total amoun water furnished by them has been in constant demand that they h earned interest. On the contrary, the protective works, which h usually proved financial failures, have been built in regions wher ordinary years the precipitation has been sufficient to produce g crops, but where during occasional years the crops suffer from lack water, and it is then only that the irrigation works are called u Such works being only utilized occasionally, produce only mode returns during occasional years. Were these works constructed less inhabited region and in one lacking sufficient precipitatio raise crops, they would doubtless then do constant duty, and it m reasonably be expected that they would become productive wor In some few cases, such as those of the Sidhnai canal in the Pun and the Betwa canal and reservoir in the Northwest provinces, w originally constructed as protective works have received such a stant demand for their waters that they are now productive, return moderate interest on the capital.

Anywhere in our arid West where irrigation works may be c structed it is reasonable to suppose, judging from analogy, that wh sufficient population settles below them, these works will be called u to furnish all the water they can provide, and if properly and caref planned and estimated for should return fair interest on the orig outlay. Only semihumid regions, such as western Kansas, the D kotas, Nebraska, and Oklahoma, have been subjected to famin These occur every few years, and are the results of the country hav been settled during periods of fair rainfall. Following these g years came a season or two of minimum rainfall when the crops w parched. It is only because of the increased transportation facil in our West and the extensive charities undertaken by the Governm and people that settlers in that portion of our country have been sa from famine. It is in such regions as those in India that the Gov ment has devoted the most time, attention, and money for the constr tion of irrigation works as a means of protection against such los and convincing arguments have been brought to prove that m expended in such protective works is saved to the Government.

The high price paid for labor as compared with that in India is argument generally used to prove that similar profitable returns fr irrigation enterprises in this country can not necessarily be expe

the cost of construction here would be proportionately so much ater as to demand a higher return from the use of water in order to ' a corresponding rate of interest. It is not improbable that with increased amount of work done by an American laborer as com- ed with that of a Hindoo coolie, and with the aid of many mechanical ·ices, the discrepancy in cost is not so great. Moreover, returns ived from irrigation works in the two countries are more nearly ıalized from the fact that we can impose a higher tax for the use of :er than it is possible to demand of the poor farmers in India, where m 2 to 5 acres support a large family. The apparent low cost of lian labor is at first glance against this argument. Men, women, and ldren are engaged alike in the construction of all works. As com- n laborers women and children receive about 4 cents per day, and n from 8 to 10 cents. Skilled masons and machinists receive from to 22 cents per day, and carpenters and blacksmiths nearly the ne.

n the interior towns of the Bombay Presidency contract prices are ɔut as follows: At the Bhatgur dam uncoursed rubble masonry costs 75 per cubic yard, while at the Tansa dam it costs $2.50 per yard. In) Northwest Provinces earth excavations in deep canal cuts cost 6⅔ ıts per cubic yard, while surface excavation costs 2½ cents. In the njab, according to the revenue reports, water in the canals yields a urn of from 70 cents to $1.25 per second-foot, while the water rate ırged per acre irrigated was from 70 cents to $1.15. In Bombay, :ording to the revenue report of 1889, the water rate derived was 15 per acre irrigated, and ranged from 35 cents to $3, the latter ure being abnormal and paid for the irrigatıon of sugar-cane crops, ıich require an enormous amount of water in their cultivation. ;ainst these prices we are able to obtain in the central arid regions America a revenue of from $1.50 to $3 per acre, which is equivalent · a duty of 80 acres per second-foot to from $120 to $240 per second- ɔt utilized. In California and other portions of the country where ıter is scarce and the crops valuable the rate is usually many times ;her than the above.

In the province of Sind in the Indus Valley, including the southern ınjab, there is an enormous and thirsty waste of sandy desert where e annual precipitation is always below 10 inches, even falling as low 3 or 4 inches. There nothing can be grown without the aid of irri- tion, and the entire area under cultivation and the population sup- ·rted thereby are entirely dependent on irrigation. The works in that gion are chiefly inundation canals with a few perennial canals mostly ken from the Indus River. In the Sind alone over 3,000,000 acres e under cultivation, and yield an annual revenue of about $3,700,000. In Bombay and the Northwest Provinces nearly double the popula- ɔn is now sustained that was supported previous to the introduction ' modern irrigation works. According to Col. Baird Smith, the whole

of the region irrigated by the Eastern Jumna canal would have devastated by the famine of 1837–38 without the aid of the irri which that canal afforded. With its aid the population was com bly supported and the gross revenue derived from the use of the was $2,445,000, of which the Government received a yearly net in of $250,000, and this shortly after the completion of the work. In same year the united Eastern and Western Jumna canals were ma ed to have saved property to the value of $10,000,000, and result of this showing the British Government shortly afterwards the construction of the great Ganges canal and other similar w From the report of Major Baker, R. E., it appears from actual urements made on the Western Jumna canal in 1838 that the value of crops on lands irrigated by that canal was $7,500,000, of w $750,000 was paid to the Government as land and water rent remainder aided to feed and support the inhabitants of 500 vil during a period of devastating famine. Without irrigation this would, during that drought, have been totally unproductive.

As an indication of the increased revenue derived from the water and the capability of the soil to pay that increase, it app that in the presidency of Madras the rate of assessment in the region is about $2.30 per acre on irrigated land, as against 55 per acre on land not irrigated. It is difficult to show in a satisfa manner what has been the actual result of the irrigation work India as financial undertakings. The figures given convey little of the actual benefit derived from the canals, as much of this is lected as the land tax, which forms nearly half the total reven the Indian Government.

Another difficulty in reviewing the financial results of Indian gation works is found in the fact that in several cases capital s by the Government accounts does not include the value of the native works, upon which the British undertakings were foun Recognizing these difficulties, Major-General Dickens presente the select committee on public works a statement of which the fo ing is a summary, which was given as the nearest approximate t truth that could be obtained. This statement was for the 1875–76 only, and no allowance was made for the value of the native works, which General Dickens stated did not exceed $2,5 The total expenditure to date was $77,500,000; the total receipts $6,150,000, and the working expenses were $2,000,000. This s that the irrigation works of India, taken altogether, paid at that a revenue, direct and indirect, of 5½ per cent to the state. includes some works which were only partially in operation. Ge Dickens anticipated that when in full operation they would eve ally pay 6 to 7 per cent.

As an indication of the time which must necessarily expire af canal work is opened and before it is doing its full duty and ret

ıg its full revenue, the great Ganges canal was fourteen years in ›eration before it paid 4 per cent on its simple capital, and Colonel rofton, the late inspector-general of irrigation in India, appears to ıink that ten years is by no means an unreasonable time to elapse 'ter an irrigation work has been put in operation before it can pay ıterest on its cost. Gen. R. Strachey in 1865 gave it as his opinion ıat it was not likely that even 5 per cent would be realized in ten ›ars on the capital stock on any but the smallest irrigation works, hile Col. Baird Smith took it for granted, in reporting on the pro›sed Soane canal, that the works would not be self-supporting for xteen years after they had been opened for irrigation.

The following quotations are from the reports of the select commis-on appointed in 1888 by the British Government to report on meas-res of protection from and prevention of famine. This report bears reat weight, owing to the high character of the members of the com-ıission, both as engineers and men of experience in the construction nd management of irrigation works and as statesmen of broad views, 'hose integrity can not be doubted. This commission consisted of Gen. Richard Strachey, James Caird, H. S. Cunningham, H. E. Sullivan, nd J. P. Peile. Their remarks relative to the value of irrigation 'orks were as follows:

It is not only in years of drought and as a protection against famine that irriga-on works are of value. In seasons of average rainfall they are of great service nd a source of great wealth, giving certainty to all agricultural operations, increas-ıg the outturn per acre of the crops, and enabling more valuable descriptions of rops to be grown. The following instances may be quoted from the mass of evi-ence before the commission: The outlay on completed canals in the Punjab up › the close of 1877–78 had been $11,300,000. The total area irrigated by them was .324,000 acres. The value of food grains raised on two works, the Western Jumna nd the Bari Doab canals, was $14,400,000. It may, without exaggeration, be reck-ned that one-half of these crops would have perished if unwatered, or would not ave been raised at all if the canals had been absent, so that in that one year alone he wealth of the Punjab was increased by these two canals by $7,200,000, an mount equal to about two-thirds the cost of the works, and but for the protection hey afforded the Government would have lost heavily from the necessity of remit-ing revenue and otherwise providing for famine relief. The net revenue for the 'ear in the Punjab was only $610,000, being about 5¼ per cent on the capital outlay n works in operation, a result which obviously supplies a wholly inadequate test f their value to the country.

Up to the year 1878 the capital outlay on canals completed in the Northwest 'rovinces had been $21,800,000. The area irrigated that year was 1,461,000 acres, he value of the crop raised on which was estimated at $30,000,000. Half of the 'rea irrigated was occupied by autumn crops, which but for irrigation must have 'een wholly lost, and it may be safely said that the wealth of these provinces was onsequently increased by $15,000,000, so that three-fourths of the entire first cost f the works was thus repaid to the country in that same year. The net revenue o the Government from irrigation in these Provinces was $1,550,000, or 7¼ per 'ent on the whole capital outlay of $28,750,000, of which about $6,250,000 was still nproductive.

The results of irrigation are not so favorable in Bengal and Behar as in the two provinces, chiefly because irrigation is there less necessary since the rainfall more abundant. There is sufficient evidence of its value in Madras. The great deltaic systems of irrigation, the Godaveri, the Kistna, and the Cauveri direct returns of 8, 6, and 31 per cent, respectively, on the capital spent on them. During the year 1876–77, a year when every unirrigated district was impoverished, large part of the food of its population, the value of rice produced in the delta the Godaveri and Kistna rivers is calculated at the prices then prevailing to have been not less than $25,000,000. The ordinary rental of land in northern India doubled by irrigation, while in 11 districts of Madras the average rental is from 40 cents to $1.70 per acre. In considering this question it should be borne in mind that there are other causes of financial ill success of irrigation works, one temporary, the other permanent. In the one case the works may fail for a time because of the slowness with which the people adapt themselves to new system of cultivation, a difficulty which arises in almost every new work because of errors in the details of the scheme which experience detects and which are easily remedied. In the other case the failure may be due to the inherent defects of the scheme and to the fact that the water costs more than it is worth. In the former case there may be reason to expect that the water will be eventually fully utilized and the deficit be converted into a surplus, though the accumulated excess charges during a series of years may amount to a large sum which the will only gradually wipe out. In the latter case, though there may be much improvement and economy in the distribution and use of the water, it may be impossible ever to realize a surplus.[a]

According to the same authorities the net income of the whole works in operation in British India was in the year 1879–80 $5,830,000, which amounts within a very small fraction to 6 per cent of the whole capital, including about $16,250,000 spent on works not yet brought into operation. If this part of the outlay be excluded the income is found to be more than 7 per cent on the capital actually utilized. Compilation of the administrative reports of the various provinces of India shows a total expenditure in the first ten years of work (1867–1877) on defined projects to have been $52,850,000. Between 1877 and 1900 the gross outlay was $285,000,000, the grand total expended on such work from 1867 to 1900 being $337,850,000. In the year 1900–1901 the expenditures on account of irrigation aggregated $11,500,000 and the revenues $12,075,000, the profit earned on the capital outlay being 7 per cent.

The following statement of the water rents derived from the use of the Western Jumna canal in the Punjab between the years 1820 and 1850 will give a fair idea of the rapidity with which the income from the use of irrigation works increases. In 1820 the water revenue was $420 per annum; in 1830 it was $28,800; in 1840 it was $112,900. On the Eastern Jumna canals in the Northwest Provinces the water revenue was in 1830 $3,000 per annum. In 1840 it was $29,300 per annum and in 1845 it was $48,200 per annum.[b]

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[a] Report of the Indian Famine Commission, Part 2, London, 1880.
[b] Smith, R. Baird, F. G. S., Italian Irrigation, London, 1855, vol. 1, 318–340.

LAND AND CROPS.

The following table gives the area and population of the principal ovinces of India according to the census of 1901:

Area and population of principal provinces of India.

Province.	Area.	Population.	Density per square mile.
	Square miles.		
ngal	151,185	74,744,866	494
nited Provinces and Oudh	107,164	47,691,782	445
unjab	97,209	20,330,339	209
entral Provinces	86,459	9,876,646	114
adras	141,726	38,209,436	269
ombay	123,064	18,559,561	151
urma	236,738	10,490,624	.....
ther provinces	143,704	11,996,343	.....
otal British territory, including Burma, etc	1,087,249	231,899,597	232
otal native States	679,393	62,461,549	92
Grand total, India	1,766,642	294,361,046	162

Of British-born inhabitants, in 1891 there were 100,551; of agriculurists, 171,735,000, or 60 per cent of the whole population; and of anufacturers, 27,470,000. The mortality in India varies from 21 to 8 per thousand.

The following table shows the areas cultivated and irrigated in the arious provinces during the year 1900–1901:

Area cultivated and irrigated in principal provinces of India.

Province.	Acres cultivated.	Acres irrigated.	Net revenue.
engal	51,607,700	716,271	$13,066,000
adras	24,509,613	6,579,284	18,854,000
ombay	21,000,594	.....	9,791,000
orthwest Provinces	25,614,892	1,800,000	15,107,000
unjab	24,521,071	6,000,551	9,561,000
udh	8,965,323	.....	5,181,000
entral Provinces	15,250,582	.....	2,908,000
ind	3,729,433	2,568,503	3,129,000
thers, including Burma	23,116,657	946,497	13,286,000
Total, including minor subdivisions	198,[illegible]1 365	19,538,923	90,883,000

Counting irrigated areas cropped twice, the total acres irri[illegible] were 32,059,993; and counting areas of all kinds cropped more [illegible] once, the total area under cultivation was 229,362,381 acres.

The following table gives the areas under cultivation of the prin[illegible] crops produced during the same year:

Extent and character of crops.

Crop.	Area under cultivation.	Crop.	Area under cultivation.
	Acres.		*Acres.*
Rice	70,093,373	Tea	[illegible]
Wheat	20,164,824	Indigo	[illegible]
Other food grains	92,566,949	Tobacco	[illegible]
Sugar cane	2,577,742	Total, including other crops	229,[illegible]
Cotton	9,614,720		
Oil seeds	12,962,072		

Irrigation works for which accounts were kept paid 7.5 per [illegible] interest in 1897–98 on the capital outlay. The estimated value of irrigated crops in that year was $150,000,000.

It will be observed from the first table that the proportion of [illegible] irrigated to the total area under cultivation is very large, one-six[illegible] the whole being irrigated. Since the introduction of improved ir[illegible]tion works and the great increase in the area of land brought [illegible] the control of these works the quantity of the more valuable food c[illegible] and more especially those which come in direct competition with [illegible]eign countries, has greatly and rapidly increased. The producti[illegible] cotton was largest in 1866, at the close of the American civil war, [illegible] the exports amounted to $185,000,000. Since then the exports of [illegible] product have decreased considerably, and now its average is on[illegible] increase and amounts to about $52,773,000. Cotton is produ[illegible] chiefly in Guzerat, the Deccan, the Central Provinces, Sind, and B[illegible]bay. The yield is as high as 100 pounds of cleaned cotton per [illegible] but the staple is short and the product is not as valuable as th[illegible] the United States.

Another crop which is being extensively exported in recent yea[illegible] wheat. It is grown generally everywhere, but does not thrive w[illegible] rice does nor south of the Central Provinces. The Punjab is the g[illegible]est wheat-producing district, then the Northwest Provinces, Oud[illegible] and Bengal south of the Ganges. In the Central Provinces w[illegible] occupies 23 per cent of the cultivated area, in Bombay and Sin[illegible] 12 per cent, and all India has an area under wheat one-third as [illegible] as has the United States. The output per acre is rather small [illegible] the Punjab it is 13 bushels per acre; in other places a trifle mo[illegible] less. Wheat is an autumn crop and is all irrigated. To the [illegible]

uction of the great canals of the Punjab and Northern Provinces is e the quality and prominence which it possesses.

Rice is an extensively cultivated crop, but it is limited to the deltas the Orissa, Godaveri, and other large rivers and to Bengal; 80 per nt of the crops raised in such regions is rice. Elsewhere little is own excepting in the lowlands along the coast. In Bengal the aver- e yield per acre is 1,200 pounds of clean rice. Millet is more tensively and generally grown than any other crop excepting in e special rice districts. A variety of sorghum called jowari and a iked millet called bajra are the most common varieties. They are et weather or spring crops and are used somewhat by the natives for od, but are chiefly used as fodder. Oil seeds form an important op. These are usually grown as a second crop after rice and pulses. il is extensively used in India for lamps and for food. The largest l-seed producing provinces are Bengal and the Northwest, but these ops are also extensively grown in Madras and elsewhere.

All kinds of vegetables and fruits are produced everywhere in India, ese being the chief food of the natives. Among the more important inds are potatoes, which are grown especially in the hills, maize, omatoes, eggplants, mangoes, oranges, lemons, melons, figs, plantains, nd cocoanuts. Cocoanut palms are grown most abundantly on the est coast lowlands, and date palms in Bengal. The production of e ordinary spices is rather abundant. They are mostly, however, or home consumption, for use in curries, etc., as tumeric, chile, chic- ry, coriander, and others. Sugar cane is very extensively cultivated hroughout India, especially in the Northwest Provinces, and in Bom- ay, but it is an expensive crop to produce, both because of the time equired to mature it and the amount of water necessary to irrigate t. The varieties of sugar cane produced in India are not equal to hose produced in America and in the West Indies, the proportion of accharine matter being comparatively low.

Jute is a plant almost exclusively produced in India and very exten- ively exported. It is chiefly grown in northern and eastern Bengal. ndigo is extensively grown in the Northwest Provinces, Punjab and Madras, chiefly by the natives. It is most extensively produced, how- ever, in Behar by English capitalists. The expense of making the lye from the plant is such that the natives are seldom able to culti- vate and manufacture it; hence the factories are usually under the control of British capital. Poppy for the production of opium is grown extensively in the Ganges Valley near Patna and Benares, and n central India. Its cultivation requires much care and attention and is usually an indication of intelligence and prosperity on the part of the cultivators. Tobacco is generally grown in small quanti- ties everywhere in India. The best is produced in Madras, whence the variety known as Trichinopoly is extensively exported. Coffee is produced in small quantities in southern India only. Tea is exten-

sively cultivated in Assam, where it is indigenous, but it is also [illegible] about Darjeeling in the foothills of the Himalayas. It is an expensive crop to prepare for market and is cultivated chiefly by Europeans. Its quality is constantly being improved and the amount exported is annually increasing.

The advantage of using manure is apparently well understood, and if not extensively used it is because of the limited means of the cultivators. The rotation of crops is not generally practiced, since owing to the extensive use of water for irrigation it does not seem to be necessary. The soil throughout India differs essentially in different localities; it is generally very fertile on the great Gangetan Plain, while the black cotton soil of the Deccan is perhaps the most fertile in the world.

The kharif or wet-weather crop is matured chiefly by the rainfall of the summer monsoon. It is sown as soon as the spring rainfall allows of the plowing of the land, and it is reaped in September or October. The rabi or autumn crop is the dry-weather crop and requires the largest amount of artificial watering for its cultivation. It is sown in October and is reaped in March or April. The principal crops produced during the wet season are rice, cotton, sugar cane, etc. During the autumn season the more hardy grains are produced, especially food grains, such as wheat, barley, etc. The millet and fodder grains are chiefly sown in the higher lands and depend for the most part on natural rainfall, as their requirements in the way of water are much less than those of other crops.

CHAPTER II.

TOPOGRAPHY, METEOROLOGY, AND FORESTRY.

TOPOGRAPHY AND GEOLOGY.

India includes within its borders the highest mountains in the world and some of the mightiest rivers and greatest plains. Topographically it may be divided into three distinct parts, each possessing different topographic features. First, the Himalayas, which form a great mountain barrier on the north and shut out the rest of Asia, forming a controlling factor in the climate and physical geography of India; second, the plains of the great rivers issuing from the Himalayas, the Indus and Ganges plains; and third, south of these plains a high, steep-sided table-land supported by the Vindhaya Mountains on the north and by the western and eastern Ghauts on either side of the peninsula. This great interior table-land is broken by many peaks and mountain ranges separated by broad and fertile valleys.

The Himalayas take their name from an Indian word which means literally "dwelling place of snow," and consist of a great mountain range 1,500 miles long, the general trend being from northwest to southeast. This mountain range may be likened to the Sierra Nevada, bordering the eastern side of the great California Valley. Approached from the southern or plains side there is the same general appearance of low, rolling foothills, the higher peaks being so far back from the edge of the valley as to be scarcely discernible. This mountain range or aggregation of mountain ranges is also similar to the Sierras in its composite formation. On top and behind it is a high arid plateau which corresponds to the Nevada desert.

The highest peak in the Himalayas is Mount Everest, 29,002 feet above the sea, while peaks above 20,000 feet elevation abound in all parts of the range. There are numerous well-traveled trails leading from India through Kashmir and Nepal into Tibet and China, and the passes on these are from 16,000 to 19,000 feet high, and for several days the traveler remains above 16,000 feet in altitude. Only one pass is as low as 16,400 feet.

The Indus River rises well north of the first great range of the Himalayas and drains nearly half of their northern slope, and after flowing around the western extremity of the range it turns and flows southwardly, being joined by various tributaries which drain the southern and western slope. Its main drainage area is situated at a great

altitude among the glaciers of the Himalayas. Its drainage basi the Himalayas alone is about 32,550 square miles in area, while its affluents the whole basin drains 311,600 square miles. This ri with its branches, affords the chief source of water supply and dra age to the provinces of Punjab and Sind.

The northeastern slope of the Himalayas is drained by the Bra putra River, which, like the Indus, rises north of the mountains, dr ing about one-half of their northern slope, and after breaking thr the Himalaya Range it flows westwardly through the valley of As to its junction with the Ganges River, 100 miles from the sea. T drainage basin of the Brahmaputra north of the Himalayas is a 95,000 square miles in area. Like the Indus, its upper basin is a great altitude. As yet its waters are but little used for irrigation. the country through which it flows generally receives a fair rain The average elevation of the Indian watershed between the headwa of the Brahmaputra and Indus rivers is above 18,000 feet in alti

The Ganges River and its tributaries drain the larger portion of southern slope of the Himalayas. The catchment area above an vation of 1,000 feet is very small relatively to that of the Indus Brahmaputra, while the total catchment area is 414,000 square m This river flows eastward through the great plains of the Northw Provinces and Bengal to its junction with the Brahmaputra, wh it flows southward to the Bay of Bengal. The southwestern slop the Himalayas, in the province of Punjab (which name means "T Five Waters"), is drained by the main five tributaries of the In viz, the Sutlej, Ravi, Chenab, Jhelam, and Indus rivers, all of w join below Mooltan, whence they flow southward to the Arabian S All these rivers are extensively used in irrigation.

The southern foothill ranges of the Himalayas north of the Pu and the Northwest Provinces are from 3,000 to 4,000 feet high, and called the Sewaliks. Between the Sewalik Hills and the sub-Hi layas is a disconnected line of valleys from 2,000 to 2,500 feet in tude. These valleys are called the Duns. The sub-Himalayas, w form a higher range or belt of hills north of the Duns and betw them and the main range, are from 15 to 50 miles in width north south, and are sometimes separated by several successive dun valleys. These latter are artificially drained and cultivated in pl and are very fertile. In the sub-Himalayas are the mountain re of the various provincial governments of India, at altitudes var between 7,000 and 8,000 feet. In a portion of the northern or Gan tan Plain to the east of the Ganges is a broad belt from 10 to 15 m wide. It is a broad, grassy tract, traversed by sluggish streams, a extensive morasses and marshes, and is called the Tarai.

The great northern plain stretches with an unbroken surface a the foot of the Himalayas from the upper Indus in Punjab to Ganges delta near Calcutta and in a wide valley along the Brah

tra called Assam. Its area is about 500,000 square miles, and it is where above 1,000 feet in elevation and appears to be perfectly flat. e northern, central, and eastern portions are well watered by rivers ving their sources in the Himalayas or in the Ghauts. Assam has eriodical rainfall, and the whole of this northern plain forms the st cultivated, the richest, the most populous, and the most civilized trict of India. This plain receives the water of four great river stems—that of the Indus, of the Brahmaputra, and the combined nges, Jumna, Sutlej, etc., draining the southern Himalaya slopes, d the Betwa, Chumbul, and Soane, draining the Vindhaya Mounns and northern Ghauts.

The third great topographic division of India is the table-land fore alluded to, generally called the Deccan, and includes the ntral Provinces, Hyderabad, Bombay, Madras, and Mysore The ghest peaks of the northern Deccan are Mount Aboo, 5,650 feet gh, on the west and Mount Parasnath, 4,450 feet high, on the east, ile the hills generally vary from 1,500 to 4,000 feet in altitude and nsist of ridges separated by broad, high plains and masses of forest. The eastern and western Ghauts are great, irregular ranges of mounins, extending the whole length of the eastern and western coasts. e eastern Ghauts average 1,500 feet in elevation; the western auts ascend sharply from the sea to an average elevation of 2,000 et, with peaks varying from 6,000 to 8,700 feet in height. The estern slope of this range is extremely rugged, having much the pearance of the mesa edges in the western United States. The stern Ghauts are a series of broken spurs, not continuous like the estern Ghauts, and afford easy access to the interior. The inner ateau between these mountain ranges is from 1,000 to 3,000 feet in evation, dotted with peaks and ranges over 4,000 feet in elevation, d it is approached through the western Ghauts by only a few difficult passes. The general appearance of this country is very similar that of northern New Mexico and Arizona and of southern Utah.

The western Ghauts form the watershed of the central plateau. nly short streams flow from them into the Indian Ocean, the main ainage making its way eastward across the central plateau, breakg through the eastern Ghauts and emptying into the Bay of Bengal. he chief rivers, viz, the Godaveri, Cauveri, and Kistna, rise in the estern Ghauts; their deltas in Madras form extensive and fertile ains, which their waters irrigate. The chief population of this cenal region is on the eastern slope, and here irrigation is extensively racticed, not only from great rivers in their lower or coast levels, ut also by means of storage in the western portions of Madras, ysore, and in Bombay. Of the important rivers of this region the rainage basin of the Godaveri is 119,000 square miles; that of the istna is 59,500 square miles, and that of the Cauveri 30,300 square iles in area.

The flood discharges of the various great Indian rivers are enor The Indus above Sakkar discharges as high as 380,000 second which is equivalent to 15 second-feet per square mile of catch The Ganges in flood may discharge 1,350,000 second-feet, wh a little less than 5 second-feet per square mile of catchme Godaveri discharges in great floods 1,350,000 second-feet, or 11 se feet per square mile; the Kistna a little less than 1,200,000 second and so small a stream as the Soane, rising in the Vindhayas, w catchment area of about 34,000 square miles, discharges 1,7 second-feet, equivalent to 50 second-feet per square mile of catch One river in southern India, the Gadanamathi, having a catch of only 29 square miles, discharges in flood 28,000 second-feet, o second-feet per square mile, and other rivers discharge nearly as relative amounts.

The following table, giving some details of discharges, etc., of ous large rivers near their mouths, is taken from Heywood:[a]

Discharges of large Indian rivers.

Rivers.	Extreme breadth of river bed.	Extreme breadth of channel.	Least breadth of channel.	Fall per mile.	Rise in monsoon.
	Miles.	*Miles.*	*Miles.*	*Feet.*	*Feet.*
Ganges	5¼	2¼	1¼	----------	27
Kistna	1½	1¼	¾	1.17	35
Godaveri	4	2½	1½	1.09	30
Cauveri	1	¾	½	3.5	12

Rivers.	Surface current in floods per hour.	Flood section.	Flood discharge per second.	Least discharge in dry season per second.	Longest duration of flood.
	Miles.	*Sq. feet.*	*Cubic feet.*	*Cubic feet.*	*Days.*
Ganges	4 to 7	288,000	1,800,000	45,000	40
Kistna	7½	153,000	1,500,000	1,125	10
Godaveri	4½	216,000	1,500,000	2,250	10
Cauveri	6	37,800	300,000	None.	10

The geology of India varies with the topography. The great ern plain is an alluvial deposit, on the surface of which not a p can be found excepting near the foot of the hills. It pro belongs to the post-Tertiary, judging from a few fossil mam fishes, and crocodiles which have been found, and is probably result of delta deposits. The Sewalik Hills also belong to geologic times and are composed of micaceous sandstones, spersed with bits of clay and marl, their age being Miocene or cene. The sub-Himalayas belong to the Tertiary epoch and a

[a] Jackson Hydraulic Works, London, 1885, p. 250.

ırine origin, composed chiefly of sandstones, argillaceous shales, ıists, and limestones. The main range of the Himalayas is comsed chiefly of schistose rocks, mica-schists, and gneiss, and some ınite and limestone.

In the Deccan the oldest rocks consist of gneiss, which is found in ·ge portions of Bengal and Madras and is pre-Silurian. The great ıss of the central plateau, perhaps 200,000 miles in area, consists of ıat is known as Deccan trap, which forms the most striking physıl feature of the landscape. Most of the great ranges of mountains, th their rugged outlines and the square buttes or ghauts and mesas, e the denuded edges of basaltic flows. It is from these jagged or ep-like ranges that they receive their name of ghauts, which means steps." The soil is largely composed of disintegrated laterite, a rruginous and argillaceous rock occurring over the trap but also und elsewhere. High-level laterite is usually a result of the decomsition of trap, and the soil of much of the central plateau which it rms is very poor in quality. Low-level laterite is more sandy, often ntaining gravel, and forms most of the better soil fringing the coast.

METEOROLOGY.

The rainfall in India is exclusively from the evaporation of the ıdian Ocean and the two bays which surround the peninsula. The stribution of rainfall is extremely variable, ranging from a couple inches per annum in portions of the Sind to over 600 inches in a mited area in Assam. By far the greater part of the rainfall is rought direct from the ocean between the months of June and Octoer by the regular periodical wind known as the summer monsoon. ı upper India the cessation of the summer rains is followed by a ıpid fall of temperature under a perfectly clear and cloudless sky. cool and dry current sets in from the northwest, down the Ganges alley toward Bengal and from the north across the northern Deccan, outh of which it turns and sets toward the Bombay coast. The plaeau of Hyderabad, Madras, and Mysore receives a small amount of ain in October and even later. In lower Bengal and on the coast a ew inches of rain are expected in October and are of importance to ıe late summer crops and in sowing or germinating cold-weather or utumn crops. The latter part of October and November and the arlier portion of winter in northern India are generally rainless. The ate winter rains, which are small in amount and are regular only in pper India, rarely set in much before January.

With regard to this periodic distribution the rainfall in different arts of India may be summarized thus: From June to September ain falls more or less heavily throughout the entire area, excepting ıpon the dry plains of the Sind, where it is extremely rare and someimes fails altogether. In a portion of the Punjab and in the Carnatic he summer rain is restricted to occasional showers. In October, when

the rains have ceased in upper India, Bengal, etc., the heavy rains Madras set in and continue until the middle or end of Decem. About this time begin the light rains of upper India, which are experienced in the Northwest Provinces and fall at intervals to the end March, after which the dry season continues till the end of June, beginning of the monsoon. In lower Bengal and in Assam the rains become more frequent from January on, and are chiefly afternoon storms. On the coast of Malabar they are earlier than in Bombay. In Madras occasional showers are expected after February, but a steady rain begins only in October.

In the Ganges delta the mean annual precipitation is from 60 to 70 inches. On the great plain, including the Northwest Provinces, averages 40 inches, and at the summit of the great plain west of Delhi it varies from 25 to 30 inches per annum. At the mountain stations in the sub-Himalayas the annual precipitation ranges from 90 to 100 inches. Farther in the Himalayas, at an elevation of 10,000 feet above, the rainfall is only 10 or 20 inches, while the snowfall may be 6 to 8 feet or more. There is a difference of from 10 to 15 inches between the precipitation over the southern and northern portions of the Gangetan Plain. In the Punjab the highest average precipitation is in the sub-Himalayas, where it is 68 inches per annum. At Multan it is but 7 inches per annum, which is a low average, and at Dera Ismail Khan the annual precipitation is 8.2 inches per annum, near the average of the Punjab. In central India the annual precipitation in the lower lands varies between 20 inches at Jeypur and 32 inches at Khundwa, while the minimum in the mountains, such as Mount Aboo, is 61 inches.

In the Northwest Provinces the general average is 26.5 inches at Muthra or Agra, while Aligarh has a minimum of 24 inches. In Bengal the maximum average on the coast is 105 inches, and the minimum average on the plains at Patna is 38 inches. In Assam at Chara Punji the maximum average of the world is reached in an annual precipitation of 368 inches, while in the same place in 1861 30 inches fell in twenty-four hours and 805 inches fell during that year. In Bombay in the western Ghauts the maximum average is 250 inches, and the minimum average in the lowlands at Duhlia is 17 inches. The general average of Bombay is 67 inches. In the Sind the maximum average of 7 inches is at Negar, and the minimum average, 4.3 inches, at Jacobabad. In Madras the highest annual precipitation is 132 inches at Manalore and Calicut; the lowest at Belary and Tuticorin is from 15 to 18 inches, the average of Madras being 44 inches.

The following average annual temperatures at different points in India indicate the tropical character of the climate and the small percentage of cold weather which prevails. At Trichinopoli and Madras on the southeast coast, the annual averages are 82.8° and 82.4°, respectively. On the southwest coast, at Goa and Cochin, the annual av-

e temperature is nearly 80°; at Calcutta it is 79.2°, and at Bombay .8°, the latter city being the coolest of the three presidency towns. the hill station of Simla, at an elevation of 7,100 feet, the average nual temperature is 54.4°. The highest monthly temperature occurs Mooltan in June, and is 95°; at Delhi it is 94.3°. The lowest onthly temperature is at the high hill stations, being at Simla 39.6° January.

FORESTRY.

In recent years the British Indian government has paid much attenon to the preservation of its forests, and is now reaping the benefit the large income derived from the sale of timber.

The establishment of the government department of forestry is of cent date, brought about by the destruction of forests for fuel, for arcoal, and other wasteful causes. In 1844 and 1847 the subject as first taken up by the governors of Bombay and Madras. In 1864 r. Brandis was appointed inspector-general of forestry, and in 1867 e regular training of forestry officers was commenced at the schools France and Germany, where it is still continued. At present disiminate timber cutting is allowed, but the burning of hill brush is opped; the forest areas are surveyed and demarked, plantations laid it and maintained, and forestry conservation otherwise carried on.

Forests are classified as reserved and open. The former are the nmediate property of the State and are managed by the forestry epartment, their development being a source of wealth. Cattle are xcluded from them, destructive crops and undergrowth destroyed, nd the cutting of timber is strictly regulated. The open forests are ess carefully guarded, but certain kinds of timber trees are protected. arge amounts of money are annually spent in the plantations, and herever needful young trees are planted to replace those removed. n 1878 there were 12,000,000 acres of reserved forests. The revenue as $3,320,000 and the expenditures $2,000,000, showing a fair net rofit. Ten years later, in 1888, there were 43,520,000 acres of State orest land, the net revenue after deducting all working expenses eing $2,020,000.

The British officials generally hold that the effect of forest denudaion on rainfall is doubtful and much disputed. Contrary to what night have been expected, there is no evidence to show whether the ctual rainfall has decreased or increased in consequence. They all gree, however, that forest destruction has acted injuriously by leting flood waters run off too rapidly and that these waters are lost. They also do much damage as floods. Three-quarters of a century go immense tracts of southern India were overspread with jungle nd the slopes of the Ghauts were universally timber clad. Most of he level woodland has since been cleared for cultivation and the imber cut down for fuel. But another and scarcely less evil has

resulted. Formerly the water was partially protected from evapo-tion by the sheltering trees. Its flow on the surface was mechan-reduced by the jungle grass and tree trunks; it had time absorbed by the vegetable mold and to sink into the earth, the insuring the permanence of the natural springs. Not till this done did the residue find its way to the rivers, and then at a comp-atively tardy pace. Now, however, as a rule the rivers are in v flood for about as many days as they used to be for weeks in mod-flood.[a]

[a] Thornton, W. T., Journal of the Society of Arts, London, 1878, vol. 26, p. 27

CHAPTER III.

HISTORY AND ADMINISTRATION.

HISTORY OF IRRIGATION WORKS.

Among the first mention made of the irrigation works of India are ose of Arab historians of the works constructed by the early Mo- mmedan emperors in the Northwest Provinces and in the Punjab. nall works, especially tanks, probably existed at much earlier dates southern India.

It is related that about 1351 A. D. the Emperor Feroze Toghlak ilt 50 dams across rivers for the promotion of irrigation and 30 servoirs for irrigation purposes. The first important canal specific- ly mentioned was built by the same emperor, and was taken from e Chouting River to Hansi and Hissar. Fifty years later this canal came partly disused after the emperor's death. The next important ention of irrigation work is that the great Emperor Akbar constructed, 1567, a canal from the river Jumna. It is stated that this canal as constructed by the aid of forced labor, but the laborers had privi- ges thereafter of using the water, and the superintendent saw that l parties, rich and poor alike, received their share. This was the st Western Jumna canal. In 1626 the Shah Jehan had the cele- ated architect, Ali Murdan Khan, construct the Delhi Canal, which llows much the same line as does the present Western Jumna. At st this canal was constructed on a high bank following the water urses, but the banks burst and the canal became inoperative. The chitect then ran a new line as far as Delhi, following the water- ed. On this canal an escape was introduced for the discharge of rplus water. It had one channel 60 feet in depth cut through solid ck. About 1753 these ancient Mogul canals ceased to exist, owing the decline of the Mogul power and to the constant wars, which at at time prevented their being kept up.

The Eastern Jumna Canal was also begun by Ali Murdan Khan and aded at the foot of the sub-Himalayas. This canal reached to Sahar- pur and beyond. It was abandoned after the first season, owing to s bad alignment, as it was constructed in the lower drainage lines d bottoms. In 1780 Zabita Khan reopened this canal, but it was rried away during the first season and was then abandoned.

The first of the modern irrigation works of magnitude was com- enced under the Marquis of Hastings in 1817, when Lieutenant laine established the head of supply of the Western Jumna canal at

a point high up on that river. This work was practically a restora of the old Mogul canal, following and using the low lines of dra to Delhi. No bridges were constructed and only earth embankm were used. The new development of these canals is due to Col. J M. Colvin, who in 1820 extended the above project beyond Delhi constructed many bridges and drainage works. Ten years la earth banks across the drainages of Patrala Sombe were replac masonry dams.

The line of the Eastern Jumna canal was surveyed in 1822 by L tenant Debude, and the canal was opened in 1830. The ancien was cleared to a depth of 4 feet below the surface level and in g a new alignment was made which was fairly good, following u highest divide or watershed. Owing to the steepness of fall giv first the levels retrograded and nearly destroyed the canal. Col Cautley rectified this by the introduction of falls, and in 1840 he in duced better works for the passage of side drainage.

Up to this time the irrigation works of India had been constr chiefly by the East India Company. In 1858 the Government gr the Madras Irrigation Company and East India Irrigation Comp per cent on the capital invested, and these companies commenc construction of works, the Government retaining considerable mand over their operations, inspecting the plans and sanctionin expenditures. Both of these experiments proved costly failures State, and in 1867 the Government purchased the works of the India Irrigation Company when the latter was practically bank The Madras Irrigation Company has succeeded only one year in ing working expenses, but still carries on work under Governm guaranty.

In 1867 the Government decided to construct its own irrig works and great activity prevailed at once, the Government irrig force being largely increased. In 1869 schemes for ten years' w involving $150,000,000 expenditures, were outlined, and the follo sums were expended: In 1867, $1,096,000; in 1868, $2,344,250; in $10,040,000, and so on. The total expenditures for the first ten y actually amounted to $52,850,000. Since then the Government w have generally proved satisfactory investments, and as they hav tainly added to the wealth and prosperity of the country and mitigated the severity of famines, large sums have been ann appropriated for the maintenance of existing works and the cons tion of new ones.

ADMINISTRATION AND LEGISLATION.

The administration of the irrigation works of India is conduc the public works department, and the engineers are all civil serv in the employ of the British Government. Their status is fix law, their promotions are usually by seniority, as in the army and n

l, like the members of those branches of the governmental service, y receive stated salaries, according to the grades they occupy. ey are entitled to leaves of absence and furloughs, and are retired h pensions after certain periods of service.

By parliamentary act of August 2, 1858, all the territory of India s vested in Her Majesty the Queen. All tributes and payments e received and disposed of in her name. In the British cabinet the retary of state for India was vested with the powers previously d by the board of control under the old East India Company régime, l later on, by act of January 1, 1877, at Delhi, India, Her Majesty umed the title of Empress of India.

The executive authority of India is vested in a governor-general led the viceroy, who is appointed by the Crown and acts under lers of the secretary of state for India. He is empowered in council make laws for all persons, whether British or native subjects, for-n or otherwise. The governor-general has a council of seven mem-rs, whom he consults in the formulation of all laws.

Of the larger presidencies the governors of Bombay (including Sind) d of Madras are separately appointed by the Crown, and have each eir own council and civil service, and in all orders they directly dress the secretary of state. Bengal and the Northwest Provinces ve lieutenant-governors and a legislative council, but these officers e appointed by the governor-general of India. The other minor ovinces have lieutenant-governors or commissioner magistrates, but councils or legislative powers. Each province is divided into dis-cts, at the head of which is a deputy commissioner. Below this icer is a commissioner and joint magistrate, a deputy collector, and nor officers.

India is divided into British territory and the native states. The rmer is governed as above described, the latter by native princes, th the help and advice of a resident at his court who is called a litical agent and whose duties are purely diplomatic. The highest ad officer in nonregulation provinces, as the Central Provinces or the injab, is a deputy commissioner. This officer collects revenues and ministers civil justice. He is the unit of administration, the sole sponsible head of his jurisdiction, and on his energy and character rgely rests the efficiency of the Indian government. In India there e 252 districts under deputy commissioners. These districts each erage in area 3,800 square miles, and have each an average popula-on of 800,000. They are divided into divisions, and these again bdivided into the ultimate unit of subdivision, which is known as a hsil. The subdivision is in charge of an assistant magistrate or ecutive officer, and the tahsil is in charge of a deputy collector or scal officer. Land is the main source of revenue of the Indian gov-nment, and hence the levying and collection of the land tax is the ain work of the administration of that government.

In Bengal permanent settlements have been largely made. zemindar or headman of a village makes the payment for the v village to the government, he taking from each cultivator his p of revenues and retaining for himself a proportion of the sam Madras the cultivator is the rent-paying unit, as the zamindar Bengal. In Bombay revenue settlement is proceeded with as where, only in more detail, by a careful revenue land survey. field is marked out, measured, and assessed separately. This m is simple, as the government recognizes only the owner of each With these owners terms of settlement are made for periods of years. In the Northwest Provinces and the Punjab the villa taken as the unit, as is the case in Bengal, and the payment is to the government by the village. Terms of settlement are also there for periods of thirty years.

In order to convey a clear understanding of the method of p ting irrigation development in India, it is essential first to give a outline of the present attitude of the English rulers toward irri At first the government permitted private corporations to cons and operate irrigation works, the earliest work planned by E engineers being undertaken by a private corporation on a guar of interest by the East India Company. During the last thirty the government has been active in the promotion and construct nearly all good works projected. These projects are studied, ex ined, and reported on usually several times during a series of y and when the government is finally satisfied with them, eit financial investments or as measures for the relief or preven famine, the work is sanctioned and the funds for its constru appropriated.

The government of India is as a rule greatly in favor of the e sion of irrigation works. It encourages enterprises by granting funds for the construction of works whenever it can be prove profits, increase of interest, and all the maintenance charges will p bly be derived. It also constructs works as a means of famine in certain places, even when profits can not be obtained. The ernment further fosters the use of irrigation waters by making water rates very low, or by even giving water away in years of sca As shown in the succeeding acts, the government of India has control over all sources of water supply, and so exercises it as to it the greatest benefit to the community at large. The powers trol over the waters for irrigation are entirely centralized.

Each province of India has a separate branch of the Public W department, known as the irrigation branch, at the head of wh a chief engineer, generally also secretary to government of that ince, and over all the chiefs of engineers is an inspector-general gation, attached to the staff of the governor-general of India. officers in the upper grades of the irrigation branch are nea

ıropeans, and are recruited from the royal engineers, or from civil gineers educated in well-known colleges either in England or India. ıe civil engineers from England receive a technical education at ›opers Hill College, and the majority of those from India are edu- ted at the Thomason Civil Engineering College at Roorkee, or at the lleges in Bombay or Madras. The lower grades of officers are com- sed of selected noncommissioned officers and soldiers and from tives who have passed an examination after studying for a period some college.

The chief engineer is the head of the department in the province, ıd this latter is divided into circles presided over by superintending ıgineers. Each circle is again divided into divisions, over which ecutive engineers preside. Each division is again divided into sub- visions, of which there are generally several under the charge of an sistant engineer. This concludes the list of the upper grades. nder the assistant engineers again come the lower grades of subor- nates who have charge of the different works.

Besides the engineering establishment proper, there is the revenue tablishment, which works in conjunction with it, and whose duties e mostly concerned with the administration and the measurement the fields for assessment. This establishment consists chiefly of ıtives, and is presided over by a deputy magistrate, under whom are lahdars, ameens, and patrols.

All of the upper grades—that is, from the assistant engineers upward, cluding the deputy magistrate—have to pass an examination in canal w, and are given magisterial powers, which enable them to inflict ınishments for breaches of this law. The powers conferred vary ith the standing of the officers. The executive engineers may pass ı estimates within certain limits connected directly with the construc- ›n or maintenance of works in their division. All estimates involv- g considerable expenditure are sanctioned by the superintending ıgineer within certain limits, beyond which the sanction of the chief ıgineer, practically that of the government of the province, is required. ll large projects, such as a new canal system or storage reservoir, ıss to the inspector-general, and are referred by him to the govern- ent of India and to the secretary of state.

The rules and regulations by which water is served to cultivators e detailed in the canal acts given further on. In irrigating districts ater is served to cultivators on certain days, very often on three days ı one week, or possibly they are allowed to use it during one week ıd are deprived of it for another. The period in which they are not lowed water is known as a period of "tatil," an Indian word mean- ıg closed. Breaches of "tatil," or the taking of water when its use is ot allowed, render the individuals committing the act liable to fine or nprisonment. The executive engineer of the division has entire con- ol over the distribution of the water, and complaints regarding scar-

city, repairs, misappropriations of water, etc., are all referred to and he either decides them himself or empowers the supervisorial officer or deputy magistrate to do so. The assistant engineer is generally a European, and his right-hand man, as far as irrigation matters are concerned, is the deputy magistrate, who is generally a native of standing and education. The assistant engineer has magisterial powers, and his time is largely employed in trying cases and settling disputes. Zilahdars, of which there are generally two under the assistant engineer, have under them 5 or 6 ameens, under whom are from 8 to 10 patrols. These latter note the fields as they are irrigated, and when the irrigation is complete their measurement is made by the ameen, the whole being superintended by the zilahdar, who is held responsible for the correctness of the measurement.

The first act bearing with any importance on irrigation legislation was Act VII, by the governor-general of India in council, passed April 12, 1845, and entitled "An act for regulating the levying of water rent, tolls, and dues on certain canals of irrigation constructed by government in the Northwest Provinces and the protection of such canals from injury." From clauses in this act the following extracts are made:

And it is hereby enacted that the said lieutenant-governor of the Northwest Provinces shall be competent to draw out rules to regulate the levy of water and the supply of water for irrigation. * * * The rules thus drawn out shall be published for general information in the Government Gazette.

And it is hereby enacted that all balances of water rent due for lands irrigated by the canal shall be levied, either by temporary deprivation of the benefits of the canal or by the same process as is prescribed for the recovery of balances of revenue.

And it is hereby enacted, that whoever willfully causes any obstruction to any of the said canals, or to any of the water courses drawn and supplied therefrom, or damages the banks of the canal, or the works constructed for its maintenance, or willfully defiles the water in the canal, shall be liable to the penalties hereinafter described.

And it is hereby enacted, that all persons offending against the provisions of this act shall be punishable, on conviction before the magistrate, by imprisonment without labor for a term not exceeding fourteen days, or fine to an amount not exceeding 50 rupees [about $25], or both: and in default of payment of such fine by additional imprisonment for fourteen days.

On May 31, 1845, the lieutenant-governor of the Northwest Provinces, under authority of the above act, passed resolutions regarding various canals, from which the following extracts are made:

In conformity with Section VIII of the aforesaid act, the superintendents of said canals are invested with the powers of deputy collectors for the levy of rents and of joint magistrates for the enforcement of penalties under the aforesaid act, and their assistants are declared competent to exercise the same powers under their directions and on their responsibility. The subordinate establishments of such superintendents have the power of subordinate revenue and police officers for the aforesaid purposes. An appeal lies direct to the commissioner of the division against orders passed by the superintendent or his assistants in the case

: deputy collector, and to the sessions judge against orders passed in the capacity : joint magistrate.

When it may be more expedient to give water on contract rather than according) the surface irrigated, the terms of contract may be as follows:

Where the water flows naturally, 2 rupees [$1] per annum for every square inch : opening taken from the summit level of the water and having a free course.

In the event of any person secretly taking water from the canal in ny manner, for which rent is leviable, without coming under engage- ıents to pay the rent, or secretly taking more water than he has ngaged to pay for, he shall be chargeable with double rates for all 'ater so taken.

All land brought into cultivation within 20 yards of the canal or any branch 'ream from it, subsequently to the construction of the channel, shall pay water ent, whether taking water or not; and similarly all land cultivated from wells 'hich have been dug or reopened within 20 yards of the canal boundary, or within) yards from any branch stream from it, subsequently to the construction of the ınal, shall pay water rent, whether taking water from the canal or not.

When, from the carelessness of cultivators either in not properly closing the eads of their water courses or in leaving the water courses in bad order, the water verflows and spreads over waste or fallow land, a fine shall be levied not exceed- ıg the highest rate of water rent leviable on the extent of land flooded.

It shall be in the power of the canal officers to close the whole of the branch 'ater courses from sunset to sunrise for the purpose of forcing the water onto the ower parts of the canal; and also, when necessary, for any period not exceeding hree days in a week. At other times the water shall be at the command of the ultivators, provided it be in the power of the canal officer to furnish a supply. 'ersons taking water once so as to benefit a crop shall be liable to the charge for he whole year, or the whole crop, as the rate may be leviable.

Special agreements between individuals and the superintendent for the use of vater for irrigation, for driving machinery, or for other purposes, on other terms han are embodied in these rules, shall be constructed as other ordinary con- racts are.

In addition to these, rules are laid down defining the powers of the ıuperintendents and their assistants and other officers on the works, ıs well as rules giving the charges which villages or individuals are ıubject to who do not take water for irrigation, but who use it for vatering live stock or for domestic purposes. The charges for filling 'eservoirs or tanks are also specified, as are the tolls for rafts or boats. The right of ownership of water was summarily settled in India in 1873 by the passage of "An act to regulate irrigation, navigation, and lrainage in northern India." The preamble tersely states the claims of the government thus:

Whereas throughout the territories to which this act extends the government is entitled to use and to control for public purposes the waters of all rivers and streams flowing in natural channels, and of all lakes and of the natural collections of still water, etc.

This statement of rights is perfectly plain, and in India the government has no need to use its power to enforce these claims. This act is known as "Northwest canal provinces Act No. VIII, of 1873," and

lays down all of the fundamental laws governing canal administra in those provinces.

The principal act establishing the laws covering irrigation i presidency of Bombay is Act No. VII of 1879, which was amend 1880 by Bombay Act No. III. The preamble reads as follows:

Whereas it is necessary to make provision for the construction, mainte and regulation of canals for the supply of water therefrom, and for the rates for the water so supplied in the Bombay presidency, it is enacted, etc.

The act then goes on to define what are understood as canals, courses, and drainage works; defines the various officers appoint law, with their powers, and makes the following further provisi

Whenever it appears expedient to the governor in council that the water river or stream flowing in a natural channel, or of any lake, or any other collection of still water should be applied or used by the government for pose of any existing or projected canal; the governor in council may, by tion in the Bombay Government Gazette, declare that the said water w applied or used after a day to be named in the said notification, not being than three months from the date thereof.

At any time after the day so named any canal officer duly empowered behalf may enter on any land, remove any obstruction, close any channel, any other thing necessary for such application or use of the said water, such purpose may take with him, or depute, or employ such subordina other persons as he deems fit.

Following this, equally broad powers are given canal offic enter or examine land in connection with projected works, to in and regulate water supply, to enforce repairs, and prevent accid Additional regulations are formulated providing for suitable crossings, the removal of obstructions to drainage, and the cons tion of drainage works. Further:

Every owner of a water course shall be bound to construct all works for the passage across such water course of canals, water courses, drainag nels, and public roads existing at the time of its construction, and of the dr intercepted by it, and for affording proper communications across it for venience of the occupants of neighboring lands to maintain such water co a fit state of repair for the conveyance of water.

This act further provides for compensation in cases of damag remission of water rates when allowable, compensation on acco the interruption of water supply, and for further causes.

Part 4 of the act lays down the rules for the levying of water and opens by stating that "such rates shall be leviable for canal w supplied for purposes of irrigation, and for any other purpose a from time to time be determined by the governor and council." cial rates are laid down to be charged where persons use water thorizedly; also when water is permitted to run to waste. Provi are made for the obtaining of labor on the canals in times of gency, and penalties are provided for damage done to canals and works.

Land tenures.—In southern India, including Bombay and Madras, hile the landholders do not own land, they possess certain rights in it, ich as the right to hold and to till it so long as they make payment of art of the produce to the government, while the government possesses ie right to a share of the land revenue. In northern India, includ- ig the Northwest Provinces, Punjab and Bengal, there is a class of iperior landholders between the cultivator and the government. The ıltivator tills the land and pays the rent to the landlord, and the ıtter pays a portion of this to the government. These proprietors re associated together in villages, with an elected or hereditary head, ho is responsible to the government for the rent of the entire village. ı Bengal there are about 130,000 landlords or heads of estates, who re entitled "zemindars," or may even be rajahs. In the central rovinces there are 28,000 separate estates. In the Punjab 1,695 emindars hold 5 per cent of the total area of that province; 33,020 illage communities hold 91 per cent of the total area, and 1,711 other ındholders have charge of 4 per cent of the total area. In the North- est Provinces the area is divided in about the same proportions mong the various classes of holders. In southern India, where the cul- ivators or ryatwari hold the land, it is leased to them for fixed periods f thirty years, though they can resign these holdings at the end of ach agricultural year. They can sell or mortgage the land, and at he death of the holder his heirs inherit the right to the lease. In Madras there are 2,392,000 ryatwari or individual tenures on which he average assessment is $5. In Bombay there are 1,367,600 ryatwari.

In these southern presidencies each village is indicated on the rev- enue map with a defined boundary, and each field is marked out and umbered on the village plan. The different classes of soil are indi- ated in colors with a description of the class of tenure, marked in a egister accompanying each map, in which are also indicated all partic- ılars of soil, tenants, and amount of assessment. The size of the ield is determined by the extent of the particular variety of soil which can be cultivated with the assistance of a pair of bullocks. Thus in light, dry soil a field will constitute 20 acres, in heavy dry soil 12 acres, and in rich garden land 4 acres. Some of the circum- stances affecting the classification of land and the value of the fields are the position of the latter with respect to the village, the facilities for agricultural operations, the character of the soil, and the oppor- tunities for irrigation.

CHAPTER IV.

EXTENT AND CHARACTER OF IRRIGATION.

CLASSES OF WORKS.

The irrigation works of India are divided by the engineer into great classes, (1) gravity irrigation and (2) lift irrigation. The first includes four great groups, namely, perennial canals, intermittent canals, periodical canals, and inundation canals. The water supply for these may be supplemented by storage works. These will be treated as a third class.

Perennial canals are taken from the rivers the discharge of which at all times suffices for the irrigation of the lands without the aid of storage. Intermittent canals are taken from intermittent streams, the water of which must be stored in order to furnish a constant supply. Periodical canals are taken from streams having an available supply during the rainy season only, and are used altogether in the cultivation of the summer crop. Inundation canals are taken from rivers having a constant discharge of some magnitude, but are fed by the rivers only when in flood.

Lift irrigation is chiefly illustrated by wells. Of these there is no to say, although the area irrigated by them is considerable. They are used in a country where labor is cheap, and are valuable adjuncts to irrigation, catching the seepage water from the canals and irrigated fields which otherwise would be wasted. Owing to the cost of lifting it is doubtful if they will ever be used to any extent in America.

Canals are divided into two great classes, those for irrigation only and those which are also employed for purposes of navigation. The conditions required to develop an irrigation canal are usually, first that it shall be carried at as high a level as possible, so as to have sufficient fall to irrigate the land to a considerable distance on both sides of it; second, that it shall be fed by some source that will render it a running stream, in order that the loss of the water consumed in irrigation may be constantly replaced in the canal. The chief requirement of a navigable canal, on the contrary, is that it shall be as near as possible a still-water canal, so that navigation may be equally easy in both directions, and no water is lost except by evaporation and absorption, and at the points of transfer from the higher to the lower levels. Hence it is most economically constructed at a relatively level. In India, among the earlier great perennial canals, it was considered the rule to make them navigable as well as irrigable, but

ie introduction of modern modes of transportation, the development f the railway system, and the construction of excellent metaled roads iroughout the country, the authorities have generally come to dispprove of the use of irrigable canals for navigable purposes.

EXTENT OF IRRIGATION.

In the presidency of Bombay, exclusive of the Sind, there are 5 irrigation works in operation, of which 3 are major protective 'orks, 7 are major productive works, and the remainder are minor rotective and productive works. The total capital outlay on these) end of year 1900–1901 was $9,170,000. The total gross revenue durig 1900–1901 was $175,200; the working expenses were $139,000; and ie net revenue was $36,200. The area irrigated during that year 'as 124,972 acres, of which about three-fifths were in autumn or dry-'eather crops. The gross revenue assessed was $1.73 per acre, and he water rate averaged $1.33 per acre irrigated. This water rate anged, however, from 35 cents to $4 per acre, the maximum price eing very unusual and due to the large amount of sugar cane which 'as irrigated on the canal where that rate was levied. The working xpenses per mile varied from $70 to $200, and the working expenses er acre irrigated varied from 30 cents to $2. The latter high figures 'ere in both cases charged on the Mutha canal, where a large amount f sugar cane was under cultivation.

In the Sind the net area cropped in 1901 was 1,873,674 acres. The rea irrigated from canals was 1,413,487 acres; irrigated from other ources, 362,913 acres; and the total area irrigated was 1,776,400 acres. 'he area under wet-weather crops was 1,439,869 acres, and under utumn crops about 366,530 acres. The irrigation's share of the net evenue for that year was $1,196,500. The financial statement for he works of the Sind for 1900–1901 was as follows:

Financial statement of Sind Irrigation Works..

'otal outlay to date	$7,994,000
'ross revenue during the year	1,071,000
Vorking expenses	266,000
Vet revenue	805,000
Vet profit, less simple interest on the borrowed capital	464,000

The average rainfall for all of Sind during the year was 4.98 inches.

In Madras the great irrigation works are constructed in the deltas of the principal rivers. The approximate cost of the works of Madras, vithout interest, to the year 1899 was $60,225,000; the total area of ultivation due to irrigation was 6,898,839 acres, and the total revenue vas $7,722,000.

In Bengal, at the end of 1901, there were in operation 738 miles of main canals, of which 495 miles were navigable; they commanded an area of 2,753,000 acres, of which 1,446,374 acres were actually irrigated. The total capital outlay on the three major works, viz, Midnapore, Orissa, and Soane canals, was $27,475,000.

In the Punjab the capital outlay to end of 1901 for major works was $38,097,000; the total net revenue was $3,333,000, or 8.4 per interest on the capital outlay. On inundation works the capital lay was $777,000, and the interest on this outlay varied from 10 cent as a minimum to 181.5 per cent as a maximum. In this prov there were 5,102 miles of main and branch canals and 11,737 mile distributaries. The working expenses were from 25 to 60 cents acre irrigated, and the establishment cost from 10 to 25 cents per irrigated. The area irrigated during the summer crop was 3,0 acres, and during the autumn crop 2,967,814 acres.

The Northwest Provinces, including Oudh, have an area of 55,000 square miles, of which 30,000 square miles may be said been protected by irrigation works at the end of the year 1894. total outlay on irrigation works in these provinces at the end of was $27,400,000; the net revenue for that year was $1,270,000, is 4.6 per cent interest on the capital outlay. The net interest on principal works—the Upper and Lower Ganges, Agra, and Ea Jumna canals—was 4.97 per cent. The total working expens the same year were $961,000. There were in operation 1,427 mile main and branch canals and 6,748 miles of distributaries. The area under irrigation was 1,799,866 acres, of which 706,221 acres summer crops and 1,093,645 acres were autumn crops. The val the principal crops was $10 per acre.

FINANCIAL AND AGRICULTURAL RESULTS.

Of major productive works, the capital for which has been prov from borrowed money, there are 35 in the six principal provi The capital expended on these works to the year 1900 was $100,000,000, while the sanctioned estimates for the completed pro were $103,572,000. These 35 major works are designed to irri when fully completed and irrigation has been fully developed, thing more than 10,356,000 acres. Of 6,000 miles of main and br canals no less than 2,300 miles are navigable. The cost of ma these canals navigable can not be readily ascertained, but shou eliminated in determining the true cost of each irrigable acre. Mutha canal, in Bombay, which is the most expensive of any can its kind, derives a considerable income from the supply of wat domestic purposes to the city of Poona. It may be said that the of this class average $9.30 for each acre irrigable. Of the 10 larg these major works, the most expensive, the Orissa system in B cost $27 per acre, and the Ganges canal, which covers the la area of all, and is at the same time the cheapest, cost a little $6.30 per acre.[a]

In addition to the 6,000 miles of main canals constructed in 35 systems, there are 18,000 miles of principal distributaries.

[a] Buckley, R. B., Irrigation Works in India and Egypt, London, 1893, pp. 29-34

ne present time only 12 of the 35 major productive works have been orked at a profit of more than 4 per cent, but the profit from these 2 has been more than sufficient to cover the deficiencies of the other 3. The net result is that the works of this class have covered the nterest charges, with a gross excess to the government of nearly 12,642,000.

For the first twenty years these modern British works were not altoether profitable. During the past ten years, however, since nearly ll have been in full operation, the net revenue return for the 35 orks together has averaged more than 4 per cent per annum on the 100,000,000 gross capital outlay.

Among the six provinces in which this class of work lies, Madras nd Sind are preeminent as those in which all the works have been peration for more than ten years and are thoroughly successful. In ne Northwest Provinces all four works are now thoroughly successul, paying over 5 per cent net revenue, and in the Punjab there is litle doubt that all of the works will finally be successful, while the older nes already pay well. One of the youngest works, the Sidhnai canal, s very remarkable in having paid nearly 14 per cent on its capital uring the second year it was in operation. Of the Bengal works litle hope can be entertained, as the normal rainfall there is too large nd too regular to make irrigation an urgent requirement for agricultural prosperity. These works must be looked on as a protection gainst occasional drought and famine rather than as a source of rofit.

Of major protective works there were in operation in 1900 in the six rincipal provinces 5 works, the capital expenditure on which was 6,866,000. These works are designed to irrigate 723,720 acres, at an verage capital cost of nearly $8 per acre. There are completed in hese systems 400 miles of canals and 800 miles of main distributaries.

Of minor works the capital of which has been provided from the genral revenues of India about 80 were in operation in 1900, distributed hroughout nine provinces, including Burma and Beluchistan. The apital expended on these works was $15,040,000 and the net revenue vas $737,000. The percentage of net revenue on the total capital utlay to the end of the year under consideration averaged nearly 5 er cent, and varied from naught in the case of some works in Bombay to 16 per cent in some of the works of Burma and 24 per cent in ome inundation canals in the Sind. These works comprise altogether ,500 miles of canals, 2,650 miles of distributaries, and render irrigaple an area of about 7,201,578 acres. The works of this class taken ollectively are more remunerative than the major productive works, which were specially constructed to pay nearly 5 per cent. The umerous small works in Bombay are unproductive, and there is but little hope that the returns derived from them will materially improve.

In 1900 there were irrigated by major productive works a 11,409,528 acres. The rate of working expenses per acre on a classes of works varied between 40 cents and $2.60. The gross irrigated by all three classes of works was 18,611,10[illegible] acres, wh entire area under irrigation, including that watered by wells an double cropped, was 33,096,031 acres. The average water rate ch was less than $1.40 per acre. The average value of crops p varied from $10 to $35, and the percentage of rate charged o value of the crop was between $3.30 and $8.25. Gaged by the st ard of the percentage of rates charged, theoretically the gage o severity of the charge on the cultivator, the Bombay rates, wh actually the highest, are shown to be the lowest, and this is rea fact because of the very high value of the sugar-cane crop so sively cultivated in that province. The gross value of the crop gated in 1900 by all the four classes of irrigation works admin by the government reached the sum of $155,000,000.

At a moderate compensation it may be said that one-half of sum is the increased value of the outturn from the fields due t gation from the canals. This figure shows perhaps more readily any other the value of the agricultural interests which are bou with irrigation works of India.

The agricultural results of Indian irrigation, and an idea of th and returns of building and operating canals can best be obtain citation of the results on a typical perennial canal, as the Sirhind in the Punjab. In 1900–1901 the amount and value of the pri crops irrigated on the British branches only of this canal are as fo

Crops irrigated on Sirhind canal in 1900–1901.

	Value.
Barley	$124,000
Maize	641,000
Wheat	1,247,000
Mixed grains	176,000
Cotton	101,000
Sugar cane	293,000
Millet and pulses	1,781,000
Fodder crops	428,000
Vegetables	222,000
Oil seeds	117,000

It will be interesting to examine the items of cost, interest, an enue of such a canal as this, and to make comparisons betwee costs and returns and what might be derived from a similar w

ıde in the United States. In making this comparison the amounts ɔorted in the revenue returns for such expenditures as pensions, furıghs, and navigation works must be deducted from the total outlay d due allowance made for the difference in cost for each class of con-uction in the two countries and for the water rate to be charged. ı the end of 1901 the total expenditure on the Sirhind canal was 9,663,000, of which $6,749,000 was interest while the work was under nstruction, and $1,000,000 was leave and pension allowance to ıployees.

Though such a work would have been constructed in a much shorter ne in the United States, owing to the substitution of mechanical ·ans for hand labor, the rates paid in our country for interest would obably equalize this charge. The total original cost of the works ıs $12,000,000, of which, exclusive of the cost of land and mainte-.nce, $400,000 was for head-works, $6,500,000 for the main canal and anches, and $1,100,000 for right of way and navigation works. The fice establishment in India is an expensive one and, less pensions, sts $2,200,000, while the tools and plant cost an additional $1,100,000. ı the main canal and main branches the earthwork alone cost ',600,000, and on the distributaries this item cost $800,000, making ',400,000 for earthworks.

For the total 1,170,000 acres of irrigable land controlled by the Sirnd canal the cost for earthwork was $4.25 per acre. Our contract ·ices in the West being, say, 10 cents per cubic yard against their 4 ·nts, this earthwork would have cost us $10.62 per acre. The masonry orks—as falls, weirs, regulators, and bridges—cost in all $2,400,000, · 83 per acre irrigated. In India rubble masonry costs about $3 per ıbic yard. In our West it averages, say, $6. Hence these works ould have cost us $6 per acre. In our works, however, we would ·oid the expense of the numerous masonry bridges constructed in ıdia; again, we would do comparatively little masonry work, but ould use iron and wood, which are relatively far cheaper. The cost ɔr these items would accordingly be proportionately less. Perhaps ue-third can be deducted for the cheaper material, and it would cost s, therefore, $4 per acre irrigated. The drainage works and escapes ɔst about 73 cents per acre more, or such a work as the Sirhind canal ·ould have cost $15.35 per acre irrigated against $8 in India.

Owing to the recent completion of the Sirhind canal it irrigates at resent only 1,170,000 acres. This, however, paid in 1900–01 a surplus evenue, after paying interest on the capital outlay, of 4.7 per cent per nnum, and of 9.1 per cent net revenue on that outlay. The water ates charged averaged 90 cents per acre irrigated. We could charge t least $2, and in some localities more. As the cost of construction in America would be twice that of India, while the receipts per acre ·ould be nearly three times as great, it is not improbable that under imilar circumstances such a work when fully utilized would yield

from 5 to 12 per cent, and when doing its maximum duty w realize as a minimum 10 per cent on the capital invested.

In addition to the amount realized from such a work as com directly with that obtained in India, there is one source of rev in our country which does not exist in India. That is the an increase in value of the land served by the canal. There is no increment available to private enterprise in India, because the ernment is the owner of the land. In America, however, when can be purchased at from $1.25 to $2.50 per acre, and when sup with water right will sell for from $40 to $100 per acre or brin equivalent revenue, the increased return from such an investme obvious.

CHAPTER V.

ALKALI AND DUTY.

OBJECTIONS TO IRRIGATION.

In 1845, during surveys for the great Ganges canal project, a committee was appointed, under instructions from the governor-general of India, for the purpose of reporting on the causes of unhealthfulness which existed along the line of the Delhi canal, and ascertaining whether injurious effects on the health of the people were likely to be produced by the contemplated Ganges canal. Their report is one of the most complete and exhaustive ever prepared relative to the effects of canal irrigation on the health of the neighborhoods irrigated. The members of the committee were Maj. W. E. Baker, R. E., president; Surg. T. E. Dempster, and Lieut. H. Yule.[a]

Among the more important conclusions reached were:

(1) That in considerable portions of the district under the influence of existing canals sickness has been largely developed.

(2) That this sickness is not attributable to the results of irrigation but to the canal works or water courses of private individuals having intercepted the natural drainage of the country, and having thus led to the formation of swampy tracts diffusing malarious influence around them.

(3) That where the soil is light and the irrigation carried on by means of main distribution channels, all the advantages of canal irrigation may be gained without the prevalence of any of those evils to be found in localities differently constituted.

(4) That if care is taken to irrigate only that land which has an open soil and which has such slope and low drainage lines as to prevent water-logging, no unhealthy results will follow irrigation.

(5) That irrigation with free surface drainage may be regarded as quite innocuous.

(6) That when malarious influences are developed by irrigation their effects are almost strictly local.

This committee recommended that the Ganges canal be kept as much as possible within soil, that is, that its ordinary surface level should be below that of the country. That earth wanted to complete embankments be never obtained from excavations made outside the canal except from such localities as would readily admit of drainage. That the canal and its branches be taken as much as possible along the

[a] Cautley, Col. Sir Proby T., The Ganges Canal, London, 1860, vol. 3, p. 24.

watershed of the country, so as not to interfere with drainage, that irrigation be prohibited in localities which appear to possess naturally a malarious character.

On this same subject Capt. Douglas Galton, of the army sanitary commission, wrote an interesting article[a] in which he gives several instances where localities that have been sandy deserts devoid of vegetation had by means of irrigation been converted into rich rice fields. For many years the irrigation measures have not been attended by any effects prejudicial to health. The subsurface water had been, however, gradually rising nearer to the surface, and at the same time fever had greatly increased. In Madras, where during drought no fever prevailed, during the southwest monsoons large districts were flooded and fevers became prevalent. It was observed in the Punjab that the fever appeared not to have been generated so much during heavy rains as from the conditions which follow them, and the remedy required is the rapid removal of water to prevent stagnation. In almost all low-lying tracts saturated with moisture the people were fever-stricken. Captain Galton sums up by saying: "The whole evidence shows the high fever death rate to be largely due to stagnating water in the soil." The objections on the score of health are, generally, defective drainage, the stagnation of the water, the deterioration of well water by infiltration, or the application of too much water. These are all remediable and within the control of the engineer.

On the line of the Mutha canals in Bombay, where sugar cane is extensively cultivated, it is found that the stagnating waters retained by the roots of the plants are producing fevers, and as a consequence the government is endeavoring to reduce the area under sugar cane, hoping thus to reduce the extent of the fever. In the North-West Provinces regular observations are made of the height of the subsoil level, and these are submitted annually with the revenue reports, indicating by the rise of this level the necessity for artificial drainage works to prevent supersaturation of the soil.

Another of the more important ill effects of irrigation is the production of alkali, or the efflorescence of alkaline salts on the surface of lands irrigated. That the effect of irrigation, however, is not altogether bad in this respect may be surmised from the following report made before the famine commission by Major Grey, C. S. I.:[b]

> Canal irrigation has rendered fit for cultivation large tracts in the Bhopal State which were utterly unculturable because of alkali, and that when these were irrigated the salts were washed off or driven into the soil.

Mr. E. O'Brien testified to practically the same effect, and stated that if properly effected canal irrigation is a cure for efflorescence. Mr. E. C. Corbin found that on lands covered by efflorescent salts

[a] Galton, Capt. Douglas, Sanitary Progress in India: Journal of the Society of Arts, 1876, vol. 24, p. 526.

[b] Report of Famine Commission, London, 1881, Appendix V, p. 4.

ıal water has eradicated the evil of alkalinity, and that land before rthless is now highly productive.

n all probability the most valuable report on the effects and causes alkalinity was that made by the "Reh" (alkali) commission for the garh district of northern India, of which Mr. H. S. Reid was presiıt, and among the members of which were Mr. Medlicott, the superendent of the geological survey of India, Mr. Burch, the director agriculture and commerce, and others. This report was printed full by Prof. E. W. Hilgard,[a] of the University of California, and substance is as follows:

Tracts rendered unculturable by excess of alkali exist more or less oughout the Northwest Provinces of India, but it is due to the roduction of extensive irrigation works that no appreciable increase the area of alkali lands is perceptible. In the earlier of these irriion works no provision for drainage was made, and they were ıply built for the purpose of affording an abundance of irrigation ter. Gradually, however, it was noted that crops began to lanish and that the lower lands were rapidly being converted into ımps, while on the higher lands alkali spots were rapidly enlarg-, while new spots were being formed where none had previously en known. The cause was apparent, and there was no difference opinion regarding it. Not only near but within even considerable tance from the canals the subsoil water level has been raised from epth of 50 feet to within a few feet of the surface. This subsure water has brought up with it by a leaching process all the alkali ts existing within the subsoil thus traversed, and by evaporation se salts were diffused throughout the many feet of substrata, accuılating at the surface to such an extent as to render cultivation profitable and even to make the soil absolutely barren, covering with a white crust of salt. While the committee agree that the st damage has been brought about by the rise of this subsurface ter by the sidewise soakage from the high-lying canals, they state ıt the trouble has been greatly aggravated by the extravagant use water by the peasants. The remedies suggested are as follows:

First, a deepening of the two canals so as to lower their water levels, d hence that of the soakage subsurface level, at least several feet low that of the land to be irrigated. Secondly, they recommend the ablishment of a system of drainage. It unfortunately happens that th of these measures frequently offer great engineering difficulties a region where, from the scantiness of rainfall, the surface conmation of the country is not favorably sculptured.

The investigations of the committee all point in one direction, viz, ıt the introduction of canal irrigation is the principal cause of kali extension, and that when the removal of soakage water takes

[a] College of Agriculture, Appendix 7, Report of 1886, Sacramento, 1886, p. 34.

place almost exclusively by evaporation, irrigation by canals end in a destructive crop of alkali where the indigenous resources the ground in that way were comparatively harmless. *As a re members of the committee almost unanimously proposed deep dr* and great importance was attached to keeping the natural dra of the country open. No dams or cultivation should be allow the natural drainage courses, and the more water that can be to flow away from the canal tracts the better, while any alkali it may carry away in solution is so far a gain. The committee a that the lavish use of canal water which the gravity-flow sy encouraged caused extensive saturation of the soil. As a re the evil effects of irrigation it becomes apparent that they are all produced by a wasteful use of water and careless alignm canals, advantage not being taken of the natural drainage country, together with careless irrigation of those portions country which are too low to afford natural drainage. It is app that alkalinity, once fairly developed, can never be cured under ing conditions of water level, and the same is doubtless true of rious fevers. The primary conditions of alkalinity and fever m expressed as defective water circulation, though mere surface age is ineffectual for the removal of alkali.

Relative to double cropping the soil the chief engineer of the Pu said in his report for 1889:

> The area double cropped on the Bari Doab canal was 14.1 per cent of th area and nearly one-fourth of the autumn crop. It seems to be slowly in which is not satisfactory, as the practice is generally detrimental and exha to the soil.

Similar opinions have been expressed by other engineers, a practice of double cropping is not encouraged unless accompan the free use of fertilizers.

Regarding the effect of irrigation on the navigation of rivers a effect on riparian rights, Col. Baird Smith states:[a]

> At the head of the Jumna canals the Jumna River carries at low seas four months, a minimum of 3,500 second-feet. The canals use 3,000 se leaving the river bed practically dry. At Agra, which is about 303 mile down the same river, the Jumna carried at the same period about 3,500 se and is an unfordable stream.

This supply is derived from subsurface drainage and seepag canals, so that the canals have not in the least affected navi The Ganges River at Hardwar carries at least 8,000 second-fe which 6,700 second-feet may be abstracted by the canal. S Narora, lower down on the same stream, and the head of the Ganges canal, the stream is large enough to admit of 2,000 secon being taken by that canal without affecting navigation.

[a] Irrigation in Italy, London, 1856, vol. 1, p. 385.

WATER DUTY AND EVAPORATION.

In discussing the source of supply the engineer has to determine the quantity of water required and the area of irrigable land. It is then necessary to determine the "duty of water" for the crops to be irrigated, the qualtity of the soil, and the loss to be anticipated from evaporation and absorption.

The "duty of water" is an expression which is used in India, as in the United States, to indicate the area of land which a fixed unit of water will irrigate, and, as in America, the unit adopted is 1 cubic foot per second of flow, or, as we express it, 1 "second-foot." In referring to the contents of reservoirs the Indian engineers usually note them as holding so many cubic feet of water, but owing to the difficulty in dealing with the billions of cubic feet which a large reservoir will store, I prefer to use the American unit "acre-foot," which is meant a quantity of water necessary to cover an acre foot in depth, or 43,560 cubic feet. In designing canals in India the expenditure is frequently reckoned per linear mile of canal, and this has been found to be generally from 6 to 8 cubic feet per mile. Such a method of computation is possible only when the main and branch lines of canals have been previously determined, as it enables the engineer to regulate the cross sections of the canal along its entire length, diminishing the same as the water is expended.

The duty of water differs greatly with different soils and crops, and is usually to be determined by the engineer for each locality. The following results indicate the variability of duty as discovered in India. On the Mutha canals, near Poona in Bombay, the duty of water in 1888, during the autumn season of four months, was as follows: Wheat required 2.18 acre-feet per acre irrigated, or the water performed a duty of 170 acres per second-foot. Sugar cane, however, required 19 acre-feet per acre irrigated, the water performing a duty of 43 acres per second-foot.

Sir P. T. Cautley, from results obtained experimentally on the Delhi and the Doab canals in 1845, discovered that for that region 800 second-feet constant discharge was a fair irrigation supply for 100 miles of length of canal, assuming that a district having an area on each side of the canal from 4 to 5 miles wide would be irrigated. On each 100 miles he discovered that the canal would irrigate 237.4 square miles, and allowing that only one-third of the area controlled was irrigated, the above supply would suffice for 820 square miles.

Before proceeding to a further consideration of the duty of water, it will perhaps be well to examine some of the theories regarding its determination. The following remarks are liberally quoted from an extremely interesting investigation of this subject made by Mr. J. S. Meresford,[a] executive engineer in the irrigation branch of the Indian public works department, Northwest Provinces.

[a] Memorandum on the Irrigation Duty of Water: Roorkee Professional Papers, No. 212, 1875.

Theoretically, 1 cubic foot of water running for a month will [illegible] an area of 60 acres to a depth of 1 foot. It is generally held th[illegible] inches is a safe allowance for one watering. Mr. Beresford is of [illegible] opinion, however, that more than 2 or 3 inches is rarely given. In [illegible] to determine the depth of moistened soil, the following exper[illegible] was made on July 25, when a fall of 5.5 inches of rain was gag[illegible] the Mankri station. About five hours after the cessation of this [illegible] fall the field examined was covered with a film of water averagin[illegible] inches in depth. Several holes were dug, and the depth of moist[illegible] soil was found to be from 16 to 18 inches. In other fields near by [illegible] from surface water, the depth was from 12 to 18 inches—that is [illegible] minus 1.5, or 4 inches of water will moisten ordinary loam to a d[illegible] of from 16 to 18 inches. A few days previously holes had been [illegible] in irrigated fields of the same soil that had been recently watered [illegible] the depth of moistened earth was found to be from 11 to 12 inc[illegible] On the 30th the 1.5 inches of standing water had disappeared [illegible] more holes were dug; one in a low place, the other where the g[illegible] seemed a few inches higher. The depth of water in the forme[illegible] 34 inches, in the latter 18 inches. The conclusion reached w[illegible] the ground absorbed the rain uniformly everywhere up to a fall [illegible] inches in ten hours, the duration of the storm referred to. Wha[illegible] in excess accumulated in low places and soaked those to a [illegible] greater depth.

Not a drop of rain had fallen before the 25th of July excep[illegible] fraction of an inch on the 5th and 9th, which softened the gr[illegible] sufficiently for plowing. Allowing 4 inches as the depth require[illegible] one watering, and that in the hottest weather, this is given only [illegible] a month—for if watered oftener a proportionately less quantity [illegible] suffice—the theoretical duty of 1 second-foot of water is 180 acr[illegible] the summer months. In the autumn, however, crops are rarely [illegible] more than two waterings, many only one, and the theoretical d[illegible] during the autumn season, allowing the watering to be lighter [illegible] in the summer and probably about as frequent, ought to be 320 ac[illegible] or the theoretical duty in the locality examined should, for the y[illegible] be 500 acres.

The actual duty obtained on the best divisions of the Ganges ca[illegible] in the neighborhood under examination is not over 160 to 18[illegible] per second-foot, or about one-third of the assumed theoretical d[illegible] There are sufficient statistics to show what the actual duty is. [illegible] next important thing is to make the theoretical and actual d[illegible] approach as closely as practicable. Considering the Ganges cana[illegible] a great machine, its principal parts are the main canal, the distr[illegible] taries, the village water courses, and the cultivator who applies [illegible] water. Each cubic foot entering the head is expended principall[illegible] follows:

(1) In waste by absorption and evaporation in the main ca[illegible]

2) In waste from the same causes in the distributaries and in the village water courses. (3) In waste through carelessness of the cultivators in not distributing the water evenly, or in allowing the ground to get saturated to an unnecessary depth. (4) In useful irrigation of the land. The object is plainly to increase the last by reduction of waste through all the rest.

From a consideration of the actual duty obtained by various experiments as compared with the theoretical duty Mr. Beresford shows that the efficiency of the canal under consideration is sometimes as low as 25 per cent. The next point established by him is the nature of the waste called absorption and evaporation, and what proportion is due to each. This discussion is extremely interesting. The loss by evaporation is the first considered. Taking a distributary 30 miles long with a water surface averaging 10 feet wide, the loss by evapora-

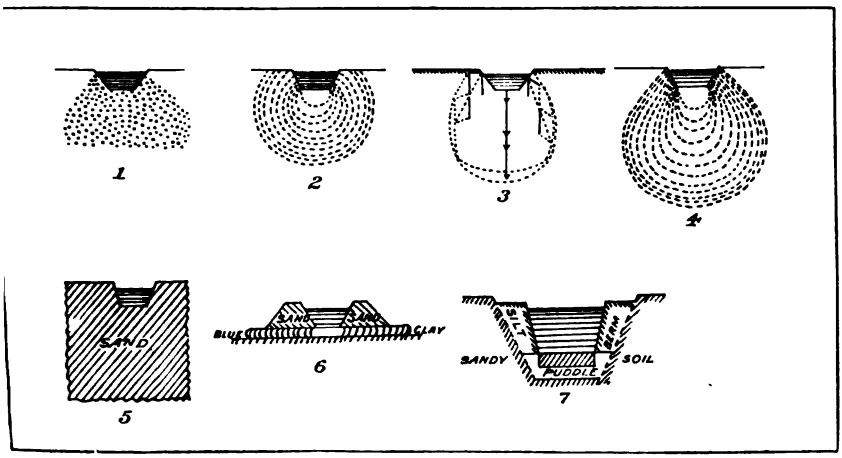


FIG. 1.—Percolation and evaporation.

tion per second in this length of water course would be 0.8 of a cubic foot by computation, and assuming that the area of water surface in the village channels equals twice the surface in a mile of the distributary, the loss by evaporation in all the village channels would be 1.6 cubic feet, or the whole loss by evaporation on the distributary 30 miles long with its minor water courses would be over 2.5 second-feet, or about 5 per cent of the probable discharge. From this we see that evaporation is not of so much consequence as far as the different channels are concerned even in the hottest weather, and may be neglected in the autumn season. The chief loss must therefore be due to percolation and absorption. The former may be said to be due to cultivation, the latter to capillary attraction.

With the aid of the accompanying illustrations (fig. 1) the following discussion will be readily appreciated. Absorption is a more complicated process than percolation. The latter takes place in bowlders

or coarse gravel in a manner similar to that by which water is through pipes or strainers in the bottom of a vessel, and the quan discharged per second will depend on the size of the interstices stones, their number, the head of the water, etc. The thicker bank through which the water is escaping, the longer and broken the channels of escape will be and the greater the fric but the question of discharge depends on the same principles as the discharge through pipes. If the gravel is considered to be br into very fine sand and the embankment formed of this material principles of discharge are quite changed. The interstices are very small and act in the same manner as do capillary tubes. empty the water rushes in and fills the cavities, and if the particles sufficiently fine they are rammed close together, and the embankm is of a certain width, the water is retained in the cavities with gre force than that due to the hydrostatic head pressing it through. T force that thus retains the water is termed capillarity, and, alth it may in reality be the same thing as gravitation, it may in this cussion be considered as quite a separate force.

Fig. 1, No. 1, represents a channel in a gravel soil or one comp of coarse sand, and the dots indicate the manner in which the would trickle through the ground. No. 2 represents what would p ably take place if the action of gravity were suspended and absorption brought to play in a homogeneous soil. But gravity, w is always in play, modifies this capillary action, and the water actually to follow the resultant of two forces. No. 3 explains action, where the straight lines and their resultants indicate the tance to which capillarity and gravity alone and combined will the particles of water, and the result would be as shown in No. 4

That absorption does not make itself more visible in high emba ments is due to two reasons, the first being that the soil in low pla is much more clayey than elsewhere, and there only are high emba ments constructed, and the second that absorption ceases when absorbing medium is limited. In an embanked channel the abs ing medium immediately stops at the outer slope, and only what evaporated is made good by absorption. If we dig a hole in a b of sandy soil, as represented in No. 5, and the hole be filled w water, this will dry up in a few moments, but if a layer of clay spread on the ground, as in No. 6, and an inclosure made with same sandy soil rammed as a natural bank and filled with water. latter will not decrease beyond what the banks at first absorb. the first instance the absorbing medium is unlimited; in the se it is limited to the soil in the embankment. It is for this reason that sandy embankments can dam up water at all. A very inter ing experiment suggested by Mr. Beresford well illustrates this act. Take a bottle and close the mouth tightly with a small piece of spo If the bottle is then turned upside down, the sponge will become

·ated, but unless pressed by the finger will give out no water. If ıother large, dry sponge is placed in contact with it, the water at once ·gins to flow through the sponge in the neck of the bottle, and this ›ntinues until the second sponge can absorb no more.

We may fairly conclude that it is the layer next the wetted perim- ›er that limits the quantity absorbed; that the greater its area the ore it will pass through to the still greater area of the next layer. verything being equal, we may say that absorption varies as the etted perimeter. Hence, for sections of canals of small length we ıay take the loss as being so much per mile, but in general the dis- ıarge and wetted perimeter decrease with the length, but the latter ot nearly in the same proportion as the former. Thus the loss up to ny point may be found when the loss between two other points is ›und. The total loss up to any point is the loss in the first mile ıultiplied by some function of the length. This, in some cases, has ›een found equal to five-sixths.

Mr. Beresford next enters into an interesting computation in which he efficiencies of the various causes of waste are considered as alge- ›raic factors with the numerical values determined as above, while he efficiency of the cultivator, which varies within wide limits, is aken as being between 0.5 and 0.9, where unity represents his effi- ·iency at the theoretical limit. He finds the loss from percolation to ›e 1.25 cubic feet in the first mile, and in long lengths of canal about ı quarter of a cubic foot per mile. The final result obtained indi- ·ates that for each cubic foot entering the distributary only 0.68 is ıvailable for fields beyond the tenth mile.

The remedies heretofore applied to lessen these defects have been few. The distributary of to-day is the same as that of thirty years ago, so far as construction of channel is concerned. The minor water courses are rarely constructed or attended by an engineer, and as a rule are badly aligned and constructed and not maintained. The cultivator is the only part of the machine which has been improved. Mr. Beresford is of the opinion that the widest field for improvement is in the minor water courses. The same applies to the private irrigating channels of the farmer of our own West. These minor channels are certainly on an average 25 per cent longer than need be. They even run a long distance through sandy ground, which absorbs a great proportion of water. The size of discharge of the module or regulator is frequently not suited to the length or conditions of the water course; and two different water courses sometimes run side by side, thus increasing the wetted perimeter and the consequent loss. The first recommendation made by Mr. Beresford is in all cases the construction of a good map. This is desired by all canal engineers, but it is rarely made, because it is thought to mean an endless amount of surveying. The saving from the construction of such a map would be more than paid for in the saving of water. It is rec-

ommended that all small water courses be puddled when run through sandy soil. A layer 3 inches thick (fig. 1, No. 7) would suffice. If the cost of this was as much as $100 per mile it would be exorbitant, for in the length of a mile, if the discharge at the head is 1 second-foot and the loss 25 per cent, the saving effected would increase the duty by from 20 to 40 acres.

The losses in distributaries, although proportionately less than in the minor channels, are often large, especially in new channels. The particles of sand or silt carried in suspension are usually dropped in the upper reach, but particles of clay or very fine sand are carried to the very tail and are often deposited on the sides and bed to a considerable thickness, forming a more or less impervious lining or silt lining. The deposit on the bed, even a long way down, is more charged with sand than is the berm. The sand being heavier, drops to the grade and as it is rolled along picks up the lighter particles of clay. It is not recommended that the sides of the distributaries be puddled unless in the first few miles, but the bed in sandy soil might be advantageously puddled everywhere to a thickness of several inches. A temporary measure suggested by Mr. Beresford is to collect clay and breaking it into fine particles, throw it in near the canal head or the falls, when the action of the water will thoroughly break up the clay and carry it into the berms and water courses miles below, and rendering them impervious.

In 1867 Mr. E. C. Palmer, executive engineer of the irrigation works, Northwest Provinces, made some interesting experiments in this direction on the Bari Doab canal.[a] Among other experiments conducted, one was made to determine the time required to saturate thoroughly an acre of ground. In these experiments the discharge orifices were 15 feet in length, each of the same dimensions and working under the same heads. The experiments were repeated on different varieties of land. It was found that an average depth of 3 inches of water over the whole surface represents a thorough watering on average soil. In sandy soil it was as much as 4 inches. This gives 10,454 cubic feet or about one-fourth acre-foot, as the volume required to water an acre. In ordinary soil the average is actually a little over 0.2[illegible] foot, or 9,150 cubic feet. In these experiments the quantity of water varied, according to the soil and other circumstances, between [illegible] and 14,500 cubic feet per acre for one watering, and the time required to water an acre varied from two to twelve hours. In the dry season wheat required four waterings and 10,500 cubic feet of water. For the first watering, in order to prepare the ground for plowing and sowing, 8,000 cubic feet were required, and the same amount for each of the remaining four waterings on the standing crop. An acre of wheat therefore, required 42,500 cubic feet to mature the crop, or nearly [illegible] acre-foot of water per acre. At the prices then current the cost to

[a] Palmer, E. C., Irrigation Experiments: Roorkee Professional Papers, No. 3.

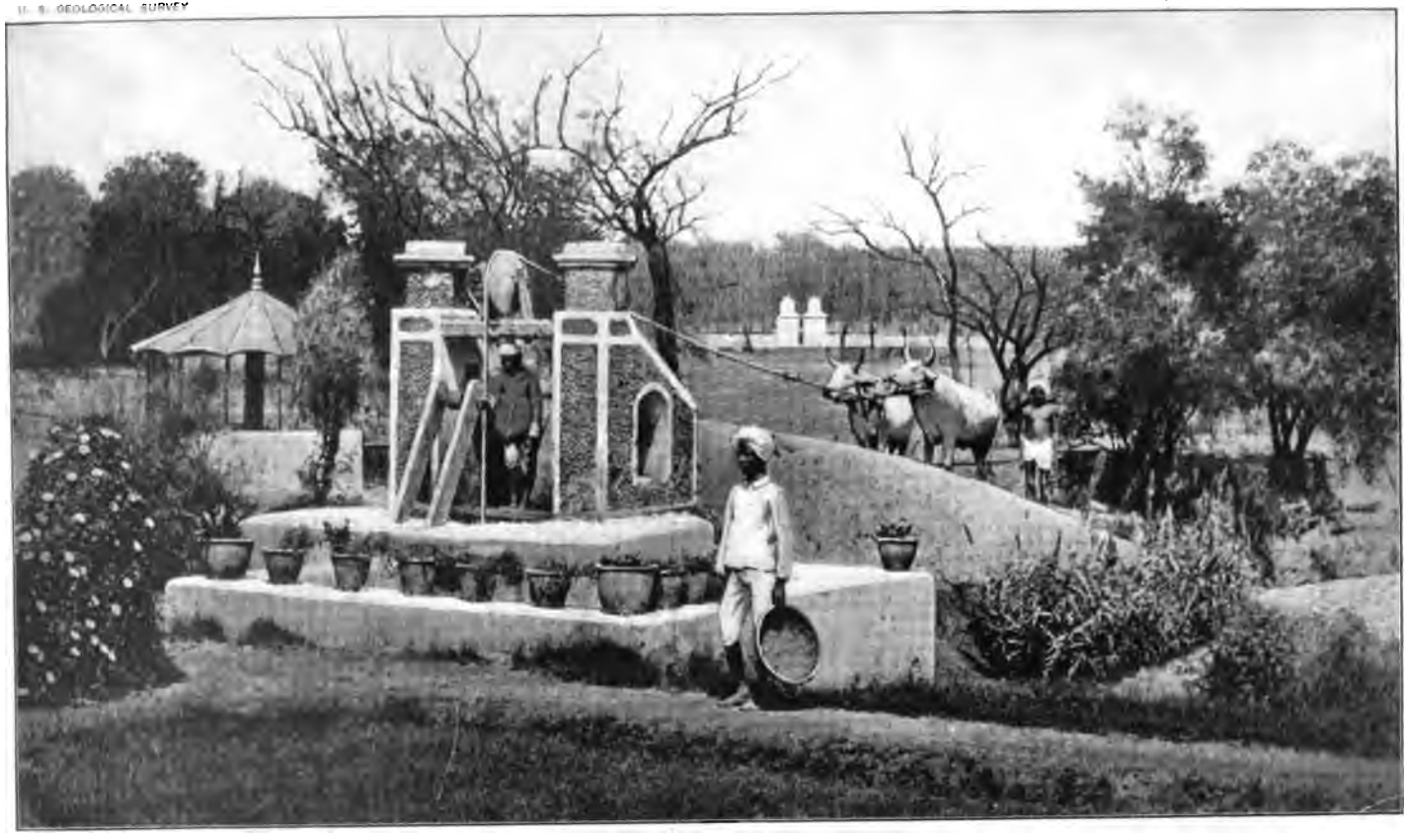
tate was 75 cents per acre and the water rate derived was $1.60 per ere. The time required to cover an acre of land was 0.445 day, or 2 acres per day. For standing crops the rate is about 4.4 acres per ay, as they ordinarily require not more than half as much water as necessary for plowing.

The losses by evaporation and absorption and the duty of water are ow well known in India on the various lines of canal and for the umerous reservoirs that have been in operation for many years. In ie Northwest Provinces the duty of water for the year 1888 varied, or different crops, from 120 to 194 acres per second-foot, and the ioney value was from $143 to $286 per second-foot. From experiments onducted on the Betwa canal in the same province it appears that ixed sugar-cane and indigo crops (which need much water) required total volume in eighty days of 310,000 cubic feet per acre for wet-eather crops, while the autumn crops required 150,000 cubic feet, or bout 3⅓ acre-feet per acre. In some experiments made on the Nira anal to ascertain the amount of wheat which could be irrigated in a iven period of time, it was found that with a second-foot of flow 8 cres of wheat could be irrigated in twenty-four hours.

In estimating the supply of water necessary to irrigate a given area of land it has been found from actual experiment that a large proportion of the land covered by any given irrigation system is always unirrigated and that water need only be provided for a certain small percentage of the total area of irrigable land. This land is not irrigated for several reasons. It may be occupied with buildings or roads or be in use as pasturage. A certain proportion receives water by seepage from adjacent irrigated fields, and another portion is occupied by towns and villages. In drawing up the projects of the great canals in the northwest it was found by data derived from experience on the Jumna canals that each second-foot of discharge was capable of irrigating 218 acres, and it was reckoned that for each acre irrigated there would be 2 other acres unwatered. Hence each second-foot represented a duty of 654 acres, or approximately 1 square mile. In drawing up the project for the Soane canals in Bengal Colonel Dickens reckoned three-quarters of a second-foot to every square mile of gross area. To date the Soane canals have been in operation fifteen years, and yet there is a demand now for not over 100 acres in 640, and the system of distributaries as designed for these canals has proved to be unnecessarily elaborate. In the Punjab it is customary to design works to irrigate only from 20 to 30 per cent of the area covered, and where water for more is demanded it is usually not given, as it is bad for the land, producing water-logging and its consequent evils. The experiments made on the eastern Jumna canal in 1845 showed that on the Saharanpur division one-fifth only of the total area cultivated was actually watered, and on the two other principal divisions the percentages were one-fourth and one-third, respectively. A similar

experiment conducted the same year on the western Jumna ca[illegible] showed that of the total area cultivated from one-half to one-th[illegible] only was actually watered.

In gaging the velocity of discharge of rivers in India floats are [illegible]ally employed. In some of the great rivers where there are weirs [illegible]structed the depth of water passing over these weirs gives a mea[illegible] of the volume of discharge; in a few cases only are current me[illegible] used. In the canals the discharge is almost invariably obtained [illegible] means of wooden floats, sometimes floating on the surface and so[illegible]times submerged. These are timed for given distances, usu[illegible] marked out in an aqueduct or other portions of the channel wh[illegible] permanent gage rods are established. On the minor distributa[illegible] V-shaped weirs are in general use for the measurement of discha[illegible]



MOT.

CHAPTER VI.

WELLS AND INUNDATION AND DELTAIC CANALS.

WELLS.

As before stated in classifying the irrigation works, lift irrigation ·om wells is extensively practiced throughout India. Wells are eco-omically among the most important irrigation works in India, because ıey are the most general. They vary in depth from 10 to 60 feet, nd may be unlined if shallow, lined with stone dry-packed, or with ıasonry.

The modes of lifting water from wells are of different kinds, viz, by ıeans of a bucket raised by a well-sweep and called the paecottah, xtensively used in Bengal; by means of a mot, whereby a leathern ag is raised from the well by bullocks walking away with a rope—method that is practiced most extensively in the Northwest Prov-ıces, in central India, and Bombay—and lastly, by means of the 'ersian wheel (Pl. IV, *A*), employed chiefly in the Punjab. As an ndication of the extent to which wells are employed in irrigation, we ind in the Central Provinces 650,000 acres irrigated from tanks, while 20,000 acres are irrigated from wells. In Madras there are 31,000,000 ıcres under cultivation, of which 5,320,000 acres are irrigated by :anals and tanks, and 2,000,000 acres by 400,000 wells. In the North-vest Provinces in 1888 the area irrigated by wells was 358,600 acres, ›r 23.6 per cent of the whole area under cultivation. In Coimbatore here are said to be 100,000 wells sunk, in many cases through hard 'ock, to a depth of 80 or 90 feet, and capable in ordinary seasons of rrigating from 1 to 4 acres each. As a contrast with the utility of :anal or tank irrigation it has been estimated that the Ganges Canal ılone replaces the work of 300,000 men and 1,300,000 bullocks, besides ncreasing the value of crops irrigated by wells by 50 per cent.

The paecottah of southern India, also called the lât in upper India ›r in Egypt the shadouf (fig. 2), is usually worked by two men who labor from six to eight hours daily. Authorities estimate that they will raise from 400 to 2,000 cubic feet per second per day. From moderate depths three men working two paecottahs will water three acres a season. The mot (fig. 4) is a leathern bucket made of a whole oxhide, and is raised by two bullocks walking down an incline and drawing after them the rope attached to it. When the bucket reaches

the surface it is emptied automatically or by an attendant. It i bay the bullocks usually return by walking backward; elsewhe are not trained to do this, and they face about to return (Pl. Sometimes two yoke of oxen are used hitched alternately to the

FIG. 2.—Paecottah.

From the Calcutta Engineers' Journal it appears that two bu working ten hours a day for a season of ninety days will rais the mot 162,000 cubic feet of water, or about 3¾ acre-feet.

The Persian wheel (fig. 3) consists of a large wheel revolvin cally in a shallow well. On its outer periphery are a large nu

A. PERSIAN WHEEL.

B. PAECOTTAH.

all buckets. These lift the water and empty it into a trough, ence it runs into the ditches. The wheel is made to revolve by

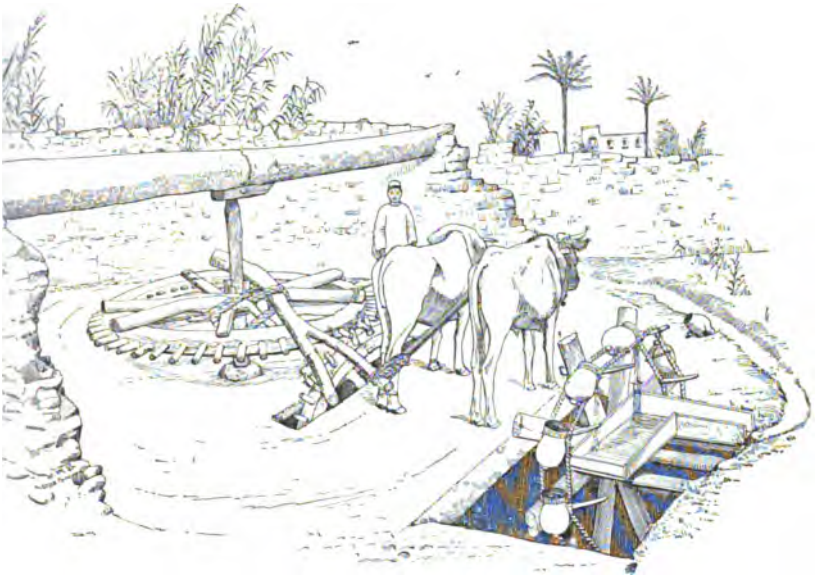


FIG. 3.—Persian wheel.

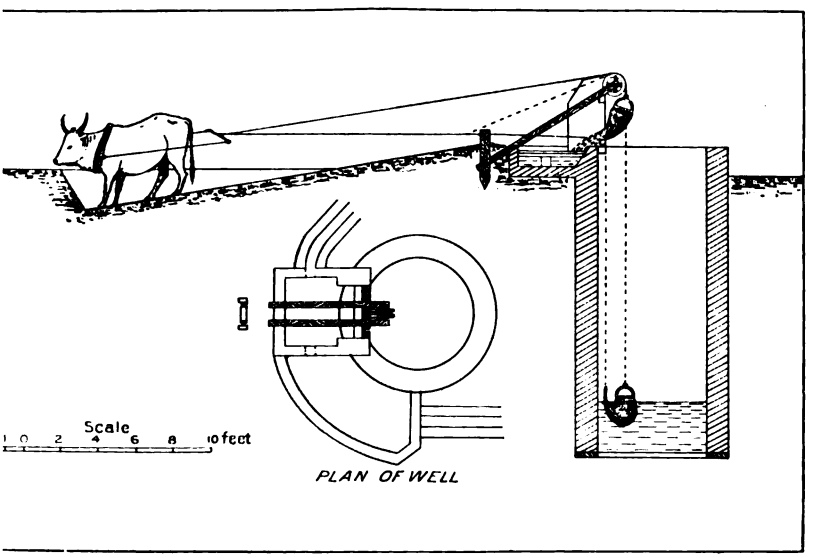


FIG. 4.—Single mot.

ans of a cogged gearing and is turned by two bullocks walking in ircle and hitched to a horizontal sweep. By this method it is esti- ted that 2,000 cubic feet of water may be raised per day.

INUNDATION CANALS.

The inundation canals of India have been constructed and are chi used in the valley of the Indus, and as they have no permanent h works they depend for their utility on two conditions generally a in the United States. First, the stream from which an inunda canal is taken must flow at a high elevation relative to the surfac the surrounding country; that is, its bed must be practically o summit of a ridge, as is the case with the lower Sacramento and M sissippi rivers. Second, the river must be subject to great an floods lasting through a long period. Inundation works have b among the most profitable canals operated in India, chiefly becau their simplicity of construction. As a general thing the inunda canals diverted from the rivers of the Punjab and Sind are us irrigate the lowlands only. Cuts are made from the river inland a certain distance, thence the canal line follows the general slo the country. By these canals the autumn crop is watered whe river is in flood. Large quantities of silt are left in the beds o canals or heaped up at their mouths, varying from 1 to 8 feet in d and this is cleaned out during the cold season. From the main c the water is distributed to the fields by branch canals and minor nels in a mode similar to that employed in irrigating from other ca

There are no works at the heads of inundation canals to contr supply of water. They are constructed on rivers whose courses a uncertain that they may at any time desert the head, when the w will have to be brought into the canal by a new mouth excavate next season. Under any circumstances the deposit of silt at the h is considerable and would naturally be increased by anything i shape of a dam. The labor in clearing the silt is a heavy a charge on the benefits received from the water and the num deserted channels in various parts of the country show that u carefully maintained these canals soon become useless.

Channels thus opening direct from the river and unprovided regulating works are subject to several disadvantages. The cu of a river may set on the mouth of the canal or on the bank and it away. The supply may become too great in the large floods or be altogether cut off owing to the destruction of the head or the ch ing of the course of the river. The violent action on the mouth o channel may be checked to a certain extent by revetments and gr and other river-training works, but these also have the effect of di ing the action of the stream from its natural course and may thr away from the canal head.

Nearly all Indian rivers from which inundation canals are div flow in broad curves through wide flood plains. At places whe curves have changed are extensive depressions containing w called *dunds* in Sind and *sotas* in Bengal. These are similar i

spects to the bayous or lagoons of the Lower Mississippi and neighring rivers. These depressions are frequently the sites of the heads inundation canals, though not infrequently such canals head in e true bank of the main river from which they draw their supply. ie object in using dunds as canal heads is that they are much larger an the canals they feed, and as the velocity through them is correondingly low, silt which would otherwise be deposited in the canal deposited in the dunds, thus reducing the cost and difficulties of nal clearance.[a]

Experience seems to have taught the native rulers of India, who nstructed most of the inundation canals, the necessity of locating ad-works at points where they would be screened from the full force the current during flood. Experiments by Colonel Tremenheere, E., on these show that: 1. Inundation canals which draw their sup-

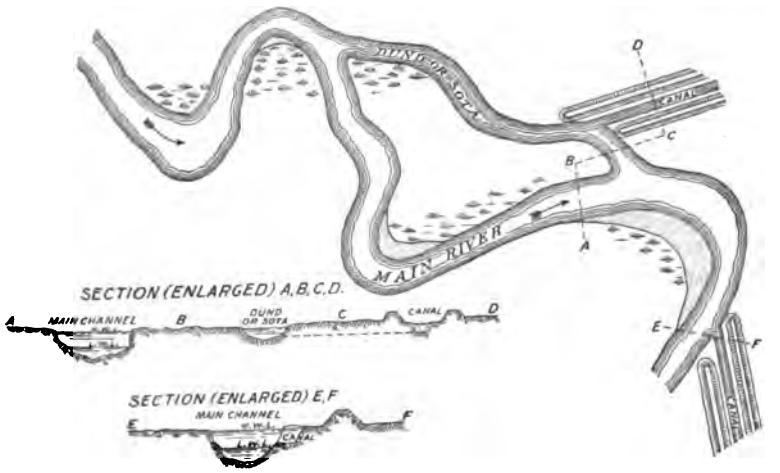


FIG. 5.—Inundation canal heading in dund.

ly from branches separated from the main river by islands covered y brushwood and long grass contain a comparatively small amount suspended matter. 2. Canals having their heads in the main ream where the velocity is normal usually contain silt to the extent one three-hundredths by weight, and that about one-third of this uantity may be deposited in the canals. 3. Canals having their eads in the main streams at a point where the channel is restricted nd the velocity increased may contain silt to the extent of one twoundredths by weight, of which one-half may be deposited in the anal.

In the Punjab the inundation canals begin to fill with water about ie last of April and run dry toward the end of September. During he earlier months, when the flood is high, lift irrigation is practiced. 'he superiority of the river water for agricultural irrigation over

[a] Buckley, R. B., Irrigation Works in India and Egypt, E. & F. N. Spon, London, 1893, p. 18.

well water is demonstrated by the fact that near the heads of the Punjab canals the cultivators prefer to pay canal rates and to lift the water from the canals rather than from wells.

The freshets in the Indus commence in March and high flood is most frequent in August. The lower stages commence at the end of October. The velocity of the current in the dry season varies from 2¾ to 3¾ miles per hour. In the freshets it is from 5 to 7 miles per hour and has sometimes reached a maximum of 8 miles. The width of the water surface of the Indus in low water or the dry season varies from 1,500 to 5,[illegible] feet, the average depth being from 3 to 6 feet. The rise of ordinary floods is from 5 to 7 feet in twenty-four hours and averages 5[illegible] feet above low-water level. The highest recorded flood was 92 feet above low-water level.

From the borders of the Punjab the Indus flows for a distance of [illegible] miles through an arid alluvial plain, almost every portion of which has at some time been swept by the river or its branches. Owing to the deposits of silt the bed and banks of the river are continually rising. It has been estimated that the Indus annually brings down sufficient silt to form an island 42 miles long by 27 miles broad and 40 feet deep. When the river bed attains a certain height the water falls over the bank and the river changes its course. It is this movement which causes the difficulties of irrigation in the Sind, and has resulted in the construction of inundation works.

Inundation canals are generally carried away from the river in an oblique direction. They vary from 10 to 300 feet in width and from [illegible] to 10 feet in depth, and resemble natural water courses more than canals. The following table gives an idea of the dimensions of some of the larger inundation canals in the Sind, and their cost and revenue for the year 1899–1900:

Sind inundation canals.

Name.	Main canal.	Discharge of canal.	Area irrigated.	Duty, acres irrigated per second-foot.	Average annual rainfall.	Capital [illegible]
	Miles.	*Second-feet.*	*Acres.*		*Inches.*	
Begari	158	5,664	186,500	55.62	0.79	$1.1[illegible]
Desert	.....	3,509	149,660	53.78	1.90	[illegible]
Ghar	298	3,210	250,000	39.24	.83	[illegible]
Sukkur	130	3,439	90,000	.....	.87	[illegible]
Fuleli	1,043	3,352	380,000	34.69	.80	[illegible]
Jamrao	101	3,200	250,000	.....	4.58	[illegible]
Total	.....	.....	1,806,160	.....	.....	[illegible]

In the Punjab the capital outlay on the five inundation works which capital accounts were kept was, to the end of 1901, $[illegible]

ıe working expenses were $197,000 and the net revenue $74,000. ıe average per cent of net revenue on capital expended on these nals was 9.58, while on the Indus and Shahpur canals an interest 23.55 and 28.76 per cent, respectively, was realized.

The following table gives the important data concerning the six ·incipal inundation canals of the Punjab:

Punjab inundation canals.

Name.	Main canal.	Discharge of canal.	Area irrigated.	Average annual rainfall.	Capital outlay to 1901.
	Miles.	*Sec.-feet.*	*Acres.*	*Inches.*	
pper Sutlej	225	9,780	247,683	13.0	$276,000
›wer Sutlej	363	5,700	271,545	6.8	
ıenab	262	4,894	130,455		
dus	713	5,164	225,000	6.6	238,000
ıelum (Shahpur)	79	1,125	42,000	12.8	72,000
uzaffargarh	886	7,284	318,225	5.2	
Total			1,234,908		

The total area irrigated in the Punjab by inundation canals was 220,000 acres, about two-fifths of which were autumn crops.

DELTAIC CANALS.

Before entering into a discussion of the perennial canals of the igher lands of India a general description will be given of the great 'orks constructed near the mouths of the larger deltaic rivers, as many f the weirs and mechanical modes of controlling water in use on them 'ill be of interest. These canals have been constructed in an almost ɜvel country, with low slopes, and are universally intended for ıavigation as well as for irrigation. Aside from the mechanical details eferred to, these canals are of little interest to the American engineer, s the conditions do not favor similar works in our country.

Deltaic canals are true perennial canals, but are here distinguished rom the latter because they are situated on a different class of rivers rom those found in the United States, and apart from the head-works, 'egulators, and other prominent works upon them do not resemble ıuch irrigation canals as are likely to be constructed in this country. As the name implies, deltaic canals usually head at the points at which 'ivers divide into numerous branches as they enter their deltaic tracts ıear the ocean, as does the Mississippi near New Orleans. A number ›f such canals have been built in India, of which several large ones ıre in Madras and two in Bengal.[a]

[a] Buckley, R. B., Irrigation Works in India and Egypt, E. & F. N. Spon, London, 1893, p. 93.

A river which runs through the soft soil of a delta easily chang course, and the relative dimensions of the main channel and its bifu cations or branches are sometimes greatly altered by floods. An ample of the extent of such changes may be cited in the case of floods on the Mahanadi River, which were carefully measured. was calculated that during the period which elapsed betwee floods of 1855 and 1872 the capacity of the Mahanadi branch diminished to the extent of nearly 80,000 cubic feet, or 10 per cen its ordinary volume. A common feature of deltaic rivers is obse in the diminution of the areas of their cross sections as they appr the sea. This is shown in the discharge at the head of any partic reach of the river being always greater than the noted discharge the heads of the branches which take off at the lower end of s reach.

There are many advantages in irrigating upon a river delta, as soil there is usually a rich alluvium and the slope of the country alw uniform and gentle. Moreover, the branches of the stream flow through the land are of uniform slope, and thus afford excellent dr for the surplus water. As the river channels flow in built-up rid somewhat above the level of the surrounding country, it is pos by throwing a weir across the delta head and running branch ca along the margins of the streams to easily command the whole c area for irrigation. As from the nature of the conditions the w area under command of the canals is subject to inundation, it is essary to confine the floods to the river channels by means of a s of marginal embankments or levees. As such rivers have a tend to change the amount of flood which they pass through diff branches, it is generally necessary to regulate the discharge of of these by weirs across both the main and branch channels. Fur more, because the cross sections of the branches reduce as approach the sea it is essential in designing levees that provision made to permit the discharge of the full volume which any bra may have to carry.

An admirable example of deltaic canal is furnished in Egypt in delta of the Nile, between Cairo and Alexandria. A few miles b the former city, at the head of the delta, is a great masonry weir, Barrage du Nil. This consists essentially of two great open reg ing bridges placed across the two deltaic branches of the Nile Damietta and Rosetta branches. The floors of these regulators at the level of the river bed, and the only obstruction offered to flo are the piers. The openings between the piers are 16.4 feet in clear, covered with arches, which carry the roadway overhead. Th are 71 spans in the Damietta barrage and 61 in the Rosetta barr The entire length of the former is 1,765 feet and of the latter feet, and these afford an obstruction to the Nile amounting to a one-fourth of the original waterway.

[n the presidency of Madras the most notable canals of this char-
;er are those at the deltas of the Godavari and Kistna rivers. On
› Godavari system there were completed, at the end of 1899, 503 miles
main canals and 1,905 miles of distributaries, which commanded
'67,200 acres and actually irrigated 653,400 acres. The total expendi-
:e on this work to end of 1899 was $4,355,000. The weir at the head
this canal was constructed in 1844. The river drains an area of
5,570 square miles above the weir, and the crest of this latter is 38
:t above mean sea level and 33 miles from the coast. The maximum
ıcharge of the river at this delta head was 1,210,000 second-feet, with
lepth of 15½ feet over the weir crest. The head-works at Doulesh-
ram consist of a weir across the river 18,000 feet in length and of
:ee sets of scouring sluices and regulators from which the three
ıin canals irrigating the eastern, central, and western deltaic regions
› supplied. The river is broken by islands to a length of 4,500 feet,
which earth embankments connect the various portions of the
ısonry weir. There are also flanking embankments, making the
:thwork in all 7,000 feet long, and there are 2,500 feet in length of
ng walls. The total length of the masonry weir is 11,946 feet. It
founded on walls 6 feet in diameter sunk 6 feet in the river bed,
d is 19 feet thick, consisting of a core of sandstone faced by a
rtain wall 7 feet high and 4 feet thick at the base, having a masonry
l 28 feet broad and 4 feet thick. Below the weir is a massive stone
ron 80 feet broad. On both banks are masonry wing walls and
:etments. The three sets of regulating sluices have the following
nensions: The eastern consists of 13 gates 6 by 8 feet, the central
15 gates 6 by 8½ feet, and the western of 15 gates 7½ feet high and
rying from 5½ to 6 feet in width. The mean supply to the eastern
lta during the summer season is 2,826 second-feet, which is the
rrying capacity of that canal. The area irrigated is 170,000 acres.
ıe maximum discharge of all the main canals during 1899 was 13,201
›ond-feet. The carrying capacity of the main central canal is 1,745
:ond-feet, and it irrigates 122,400 acres. The supply of the western
nal is 3,950 second-feet and it covers 319,580 acres. The canals vary
bottom width from 114 feet on the central canal to 225 feet on the
:stern canal, with varying depths of from 7 feet on one to 10 feet
the other.

The River Kistna has a course of about 800 miles from its source in
itude 18° 01′ and longitude 73° 14′, down to the sea, about 45 miles
ıth of Masulipatan on the Coromandel coast. Its drainage area
ıy be taken at 97,050 square miles, and its maximum flood discharge
820,000 feet per second (fig. 6).

The idea of damming this river by an anicut at Bezwada, 60 miles
ove its mouth, where the configuration of the country lent itself in
exceptional manner to the construction of such a work, was first
›oted in the year 1792, but nothing was definitely decided until 1847,

when Maj. (now Sir) Arthur Cotton and Capt. (now Sir) Atwell L. submitted a joint report on the proposed anicut and on the scheme irrigation for the eastern and western deltas. After considerable cussion the court of directors sanctioned the construction of the an together with subsidiary works, on the 5th of January, 1850, for a of $513,000. The head sluices and locks were commenced in 1852 completed in the following year. The anicut itself was commenced in November, 1853, and completed in 1855, in spite of great delays losses caused by an extraordinary flood and an outbreak of cholera.

The head-works consist of a weir 3,198 feet in length, and the greatest flood rose 19½ feet above its crest. The eastern main canal

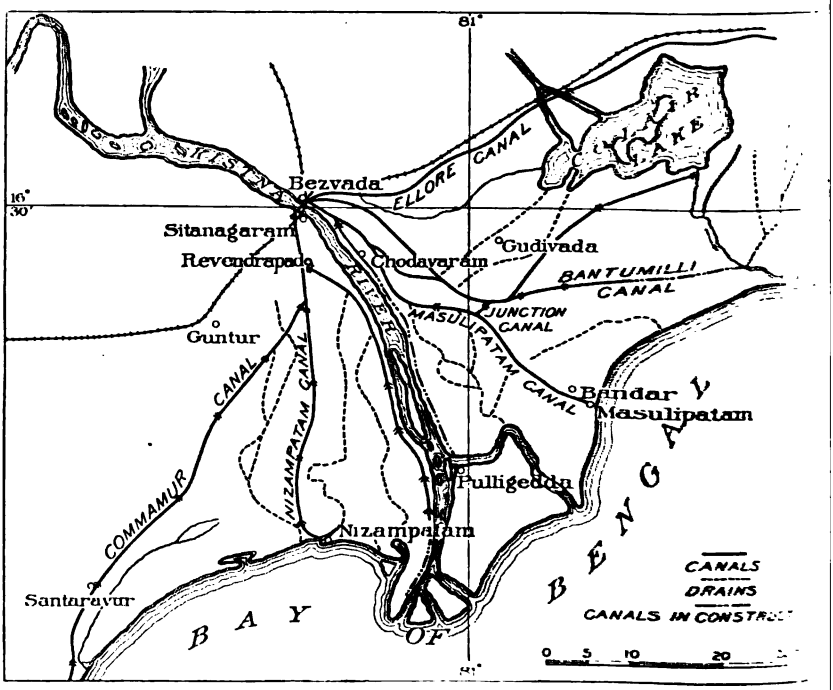


FIG. 6.—Kistna canal system.

bottom width of 200 feet and a depth of 8¼ feet. The western has a bottom width of 230 feet and a depth of 8 feet. The total of main canals in 1899 was 372 miles and of distributaries 1,625 The total area of irrigation in 1899 was 505,087 acres. The crest weir at the head-works is 6 feet in width and 15½ feet above the the foundation. The total width of apron below the crest is 2 (Pl. V, A.) The foundation consists of a double row of wells, at each end of the weir is a set of scouring sluices of 30 gates, each wide. The regulating gates are of the same dimensions. The of the weir being too low for the required supply, a temporary stone wall 4 feet high is annually built on it, and after the stoc

A. KISTNA ANICUT, WITH RIVER IN MODERATE FLOOD.

B. HEAD SLUICES OF EASTERN CHANNEL FROM KANIGIRI RESERVOIR.

een washed off by floods it is used in the repair of the apron. Shut-ers have recently been substituted for this temporary device.

The Cauvery deltaic canals, from the river of that name in Madras, rigated 919,540 acres in 1899. The length of main canals is 844 iiles, of distributaries 1,250 miles, their maximum discharge being 1,060 second-feet. So far the cost of these works has been $704,000.

The data upon which the size of the head sluices and main canals ere calculated was 2 cubic yards of water per hour per acre, or a uty of 66 acres per cubic foot per second. This, it was calculated, ould be maintained for the ultimate proposed area of irrigation of 70,000 acres throughout the irrigation season except for about forty ays in the year. Experience, however, has proved that, owing to he heavy clayey nature of the delta soil and care taken in the distri-ution of the water and its utilization by the ryots, that a duty of 90 cres per cubic foot per second may be reckoned upon, pointing to n ultimate development of no less than 700,000 acres, or 50 per cent n excess of the originally calculated irrigable area.

The East Tamileru escape or Chattaparru outlet at 40 miles 20 hains, Ellore Canal, eastern delta, was built in 1890–91 to provide or passing the flood water of the east branch of the Tamileru out of he canal. The work consists of four arches, 20 feet span each, at ither end, and eleven small arches between 7½ feet span each, the atter fitted with screw-gearing shutters. There is a footbridge over he entire work.

The Sangam anicut project was sanctioned in 1881 for the purpose of improving nd extending irrigation in the northern section of the Penner River delta. Its rincipal features were the construction of a weir 4,290 feet long; a head sluice of 0 vents, of 4½ feet span each, to supply the main canal; the excavation of a main anal 6 miles long and 157 feet bottom width, to fill the Kanigiri reservoir; mprovements to an existing branch channel, which was to be supplied from the nain canal; raising the banks of the Kanigiri reservoir, to increase its capacity, nd the excavation of distributaries from the Kanigiri reservoir and Duvur tank. The anticipated ultimate area of irrigation under the project was 94,000 acres roducing a net revenue of $78,900.

The works have been carried out more or less as they were designed. The pro-ect came into operation in 1886–87, and there has been a steady increase of cultiva-ion, except in 1891–92, when there was a falling off, owing to the scarcity of water, which amounted nearly to famine in the Nellore district. According to the eturns of 1895–96 the area irrigated was 77,347 acres and the net revenue, after leducting working expenses, amounted to $44,000.

Sangam anicut is built across the Penner River at the village of Sangam and onsists of a solid wall of masonry with scouring and head sluices, all founded on wells. The rear of the anicut is provided with a substantial sloping apron built of large bowlders with the interstices filled in with concrete and strengthened by binding walls.

The length of the anicut crest between south wing and scouring sluice is 4,076 feet; top breadth, 4½ feet. The upper course is built to a thickness of 2 feet, with cut laterite set on edge in Portland cement. The crest is 7 feet above deep bed of river, or 10.50 feet above M. S. L. The anicut has been designed to discharge

597,000 cubic feet per second and the wings and other masonry works at it have been built to meet the contingency of an additional 5 feet rise of the river during extraordinary floods. The scouring sluice, which is built tinuation of the anicut, is constructed of brick in surki mortar, except the and apron, which are paved with cut stone, and the sides and faces of piers with cut laterite. It is provided with 14 vents, 6 by 6 feet, which are closed by means of screw-gearing shutters. The under sluice is also intended pass down the regulated share for the Nellore anicut system lower down the

The Sangam head sluice is built in similar style to that of the scouring and has 21 vents, 6 by 6 feet, for the regulation of water into the K main canal, which supplies the Kanigiri reservoir. It has been designed ply water for the irrigation of 94,000 acres by a discharge of 4,800 cubic second when water in river is flush with anicut crest. The floor level sluice is 98′ M. S. L., or 2 feet above that of the under sluice.

Kanigiri tank head sluice, southern channel, is intended to discharge water for the irrigation of 17,500 acres under southern channel and under branch or central channel. It is built of brick in surki mortar, the and apron being paved with cut stone. It is provided with 4 vents, 6 by and worked with screw-gearing shutters. Eastern channel head sluice is brick in mortar with the exception of the floor, which is paved with cut and the piers cased with cut laterite. [Pl. V, *B*.] It has 16 vents, 6 by capable of discharging 934.5 cubic feet per second when the reservoir m F. S. L., the area to be irrigated under the channel and its branches bein acres. The supply of water to the channel is regulated by means of screw The sill level is 73′.

Kanigiri masonry dam or flush escape [Pl. VI] is intended to pass the sur the reservoir over rocky ground, and is built entirely with rubble in surki the crest being placed 2 feet below F. S. L. (94′.95) of the reservoir, or 92 but in order to maintain a full supply, grooved iron standards have been top, provided with planks for raising and lowering the water as required length of the dam is 280 feet, with a top breadth of 4½ feet.

Kanigiri escape sill is placed on the same level as the crest of the masonry and acts jointly with it. The masonry is composed of brick in surki mortar ing on rock foundation. The escape consists of 31 arches of 9 feet span roadway on top, and in front screw-gearing shutters have been fixed to the water to F. S. L.[a]

The principal remaining deltaic canals in India are the Midna and Orissa canals in Bengal. According to the revenue rep Bengal for the year 1901, it appears that the total capital out date on the Orissa canals, exclusive of interest charges, was $17,4 and on the Midnapore canals, $5,953,000. The Orissa canals originally constructed by the East India Irrigation and Canal pany and the source of supply is derived from three principal riv the Mahanadi, the Brahmini, and the Byturni. The minimum charge of all these rivers during the cold weather or autumn 6,612 second-feet, and the maximum discharge of the canal is second-feet. The gross area commanded is 597,792 acres, of wh present 274,974 are irrigated. The works consist of 280 miles of and branch canals and 1,123 miles of distributaries. There are distinct weirs at the head of this canal. One at the point wh

[a] Administrative report Irrigation Branch: Public Works Dept., Madras Presid

KANIGIRI RESERVOIR ESCAPE.

iver bifurcates is 3,600 feet in length and 12 feet above the river bed. 'he second weir is across the Mahanadi River itself, and is 1¼ miles ›ng and 12 feet high. The third, across the Biropa River, is 1,980 ›et in length and 9 feet above the river. The system of canals is apable of great extension.

The Midnapore canal was also constructed by the East India Irriation Company. Its supply is derived from the River Cossye, the atchment basin of which is so small that the supply of water in the anal varies with the rainfall on the district covered by the canal self. The works were commenced by a company in ignorance of the eal supply available, and the distributaries have actually been contructed to command an area of 180,000 acres, of which 125,000 are at ›resent irrigable.

The canal is divided into four lengths, the first of which is taken off bove the weir at Midnapore. In the twenty-fifth mile this tails into he river where the second weir is built across it. The canal crosses he river at this point and the second length is diverted on the oppoite bank. A large portion of the remaining length of the canal is onstructed principally for navigation. The automatic sluice gates onstructed in the weir at Midnapore are of peculiar interest and will ›e fully described in another place.

Deltaic canals.

Name of canal.	Province.	Main canals.		Area irrigated.	Rainfall.	Expenditure to 1901.
		Miles.	*Discharge, sec.-ft.*	*Acres.*	*Inches.*	
)rissa	Bengal	280	6,058	274,974	75.8	$17,436,000
ſidnapore	do	72	1,500	125,000	59.6	5,953,000
ſodavari	Madras	503	13,478	662,210	42.8	4,355,000
Ǩistna	do	372	8,942	547,806	27.4	4,465,000
›enner	do	31	6,634	145,470	30.1	1,987,000
›alar	do	163	5,546	45,206	25.2	697,000
Ǩurnool	do	190	1,440	62,098	25.2	7,275,000
'auvery	do	844	45,525	919,539	52.3	919,000

CHAPTER VII.

PERENNIAL CANALS.

SOURCE OF SUPPLY.

Perhaps the first consideration in designing any irrigation work is the source of supply. In the case of perennial canals this may be from perennial streams or from storage reservoirs. In either case the Indian engineer deems it necessary first to make a thorough examination of the hydrography of this source to ascertain the quantity of water available and the point of the river's course at which the canal can be taken off. The head-works are almost invariably located high up on the river to command a sufficient level and if possible to tap the stream where the water is clear and not laden with silt. By thus locating the head-works it is usually possible, owing to the greater slope of the country, to reach the high lands or watersheds of the areas to be irrigated with the shortest possible diversion line. By diversion line is meant that portion of the canal's course which is necessary to bring the line to the neighborhood of the irrigable lands and which is usually unprofitable, as it does not irrigate directly any land. The disadvantages of locating the canal head-works high on the streams are serious. The country having an excessive slope requires rough hillside cuttings, perhaps in rock, and the line is moreover, intersected by hillside drainage, the passage of which entails serious difficulties.

Perennial canals are taken chiefly from the great perennial rivers which issue from the Himalayas, from whose melting snows the canals receive an abundant and constant supply of water. The smaller perennial canals in portions of Madras and Bombay are chiefly fed by storage water collected in reservoirs and tanks in the hills. The great rivers of the Punjab and the Northwest Provinces rarely discharge less than 4,000 second-feet, and some discharge many times this volume, while in times of flood their discharge increases to as high as 1,200,000 second-feet and more.

In the arid region of the United States no such streams as these exist, though a few of our great rivers, as the Missouri, Columbia, Rio Grande, Sacramento, and their principal branches, carry large volumes of water, much of which it is to be hoped will at some future time be utilized for irrigation. Because of the similarity existing between these and the great Indian rivers, the country which they traverse, and its climate during the cultivation of the autumn crop

ie use of the waters of these great streams will be of immediate iterest to us and may furnish useful lessons and examples when we ommence the construction of similar works. The topography of the 'unjab and Northwest Provinces at the foot of the Himalayas has een described in detail in another place. It is very similar in many espects to that of the great California Valley on the western slopes f the Sierras and that of the Colorado and Wyoming plains at the ot of the Rockies. The rivers issue from the sub-Himalayas and ewaliks through foothills similar in appearance and with surface lopes corresponding to those of the Feather, American, Stanislaus, nd other rivers flowing from the Sierras in California, or to the rkansas and Platte rivers issuing from the Rockies.

In designing these great perennial canals the Indian engineer first iakes a careful topographic survey of the entire region to be irriated, and numerous trial lines are run before the final location of the iain and distributary canals is decided upon and the position of the ead-works definitely fixed. In the case of the rivers having a contant regimen training works are unnecessary, as the head-works are enerally located in narrow portions of the river where the banks are irm and the channel stable. At the entrance to some of the larger anals heading in the plains, notably the Agra and the Lower Ganges, xpensive river-regulating works are required to control the moveients of the river channels.

The machinery of a great canal consists usually of the following arts: The head-works at the point where the canal is diverted from he river, the main canal, the distributaries, and the minors. Each f these units of the system has its own set of regulating works and scapes to control the supply of water in the canal. Between different anals these differ but slightly, the point of greatest difference usually eing at the head-works and in the first few miles of diversion line. Iere various devices have been resorted to for the passage of hillside lrainage.

GANGES CANAL, NORTHWEST PROVINCES.

It is probable that the first attempt to construct a canal on the interluve between the Ganges and Jumna rivers occupied by the present ine of the Ganges canal was made by Mohammed Aboo Khan at some ime early in the eighteenth century. This canal consisted of a shalow ditch 12½ miles long taken from the west Kali Nadi and was filled by means of a temporary weir thrown across that stream. No masonry works were constructed, and much damage was done by the flooding of lands above the weir. The second attempt here made was in 1827, when Captain Debude tried to restore the above by putting in permanent head-works across the Kali Nadi. This plan contemplated the extension of the canal through Meerut to Aligarh, and it was also intended that a dam should be thrown across the Hindun River and

the water of both streams utilized. This was merely an attemp[illegible] improve on old and bad methods. The third and present projec[illegible] purely a British one. In 1836 Col. John Colvin, C. B., propos[illegible] build a canal from the Ganges River heading at Hardwar.

The famine of 1837 and 1838 caused an increased desire for the [illegible]struction of this canal, and in 1839 Lord Auckland, the Gover[illegible] General, sanctioned the surveys. In 1840 Sir P. T. Cautley made [illegible] first surveys and reported on the project, and from then to 1845 a[illegible] $50,000 per annum was expended chiefly on surveys. In his rep[illegible] Colonel Cautley said:

> To deny the value of irrigation to agriculture in an arid country is like [illegible]ing the value of manure to an European farmer.

On the strength of the report made in 1840 the board of dire[illegible] decided on the construction of the Ganges canal as an irrig[illegible] work, the canal as sanctioned being designed to carry 6,750 seco[illegible] feet. When Lord Ellenborough was Governor-General, between [illegible] and 1843, he did everything to discourage the project and so modi[illegible] the sanction that only a small navigation canal could be constru[illegible] During Lord Ellenborough's governorship to 1847 Colonel Cautley [illegible] in England attempting to further the project, and the works [illegible] carried on by Major Baker. In 1848 Lord Harbinge became Gove[illegible] General, and sanctioned the work as originally devised, urgin[illegible] immediate construction, which was at once prosecuted by Co[illegible] Cautley.

In 1845 Colonel Cautley submitted detailed estimates for thre[illegible] arate projects, in each of which the discharge at full supply wa[illegible] be 6,750 second-feet, of which it was assumed that 1,000 second-f[illegible] would be lost by evaporation, absorption, and navigation. The [illegible] of these projects was estimated to cost about $4,670,000 and re[illegible] irrigable an area of 1,470,000 acres. When in 1847 the Governm[illegible] directed that these works should be constructed, among other ins[illegible]tions they said that the primary object of the canal was to be irri[illegible]tion, navigation being carried only as far as not inconsistent [illegible] irrigation, thus reversing the instructions of Lord Ellenboro[illegible] government.

Water was first admitted into the canal in 1854 and irrigation [illegible]menced the following year. During the next few years defects i[illegible] works gradually came to light, and in 1864 an investigation [illegible] ordered by the government. At the close of that year detailed e[illegible]mates were submitted for rectifying the principal of these defe[illegible] Previous to this Sir Arthur Cotton reported on the works consid[illegible] by him necessary for the improvement of the canal. In his rep[illegible] stated that the head of the canal was too high up on the river: [illegible] the whole canal had been so cut as to carry the water below the l[illegible] of the surface, entailing a vast unnecessary excavation; that the w[illegible]

[a] The Ganges Canal, 3 vols., London, 1860.

f the water was admitted at the head, so that it was conveyed in places 50 miles to the land to be irrigated, and that there was no permanent am across the river at the canal head so as to secure the supply of ater. In addition to this Sir Arthur Cotton enumerated 14 minor efects in the canal. In 1868 the attention of the government was rawn to the question again by a note from Colonel Strachey, in which e pointed out that though the existing Ganges canal was able to ipply the upper portion of the interfluve, there would be tracts lower own to which the available water in the river could hardly be dis-ibuted by the construction of a lower canal, as suggested by Sir rthur Cotton. This led to the projection of the system of works

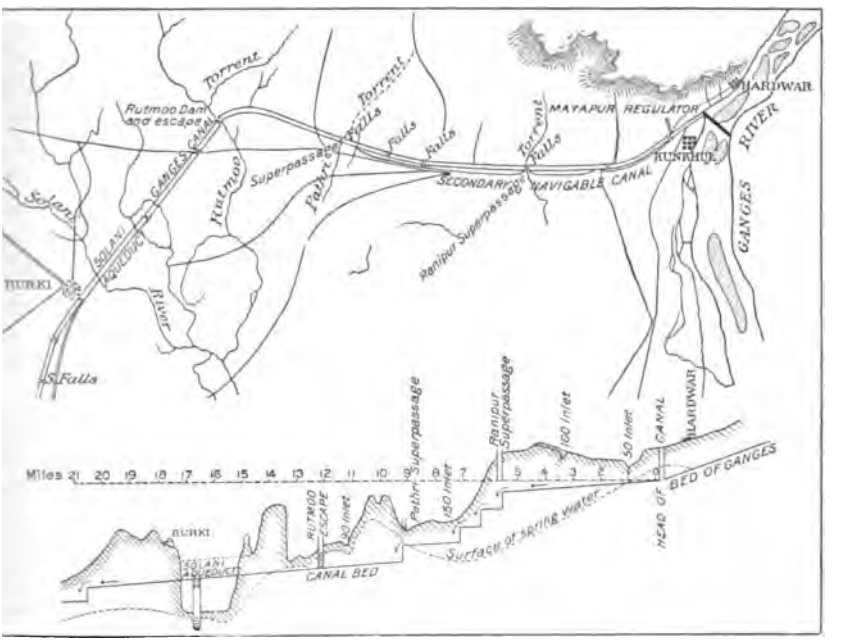


FIG. 7.—Plan and profile of Ganges canal, Hardwar to Roorkee.

nown as the Lower Ganges canal and to material alterations in the neasures for rectifying and completing the old Ganges canal.

This canal is the largest in existence. As at present constructed its ead-works are situated near the city of Hardwar, about 20 miles bove the railway town of Roorkee. At this point the Ganges issues uddenly from between the foothills of the Himalayas onto the broad evel plains. In the first 20 miles of its course (fig. 7) the canal encounters a considerable amount of sub-Himalaya drainage, and the works for the passage of this drainage and for the reduction of the slope of the canal by means of falls are important. The slope of the river bed in this section is from 8 to 10 feet per mile

A short distance above Hardwar a branch of the Ganges about 300

feet in width separates from the main river and, hugging the Has[illegible] shore, rejoins the stream a half mile below Hardwar. The disch[illegible] of the main river at this point in the dry season is about 8,000[illegible] feet, the greater part of which is diverted by training works and [illegible]porary bowlder dams into the Hardwar channel. This has [illegible] deepened and given a uniform slope of 8½ feet per mile to the [illegible] head. At Myapur the canal is taken from the Hardwar channel [illegible] water being diverted into it by means of a weir and sluices acr[illegible] channel and a masonry regulator at the head of the canal. To the [illegible] mile the canal crosses several minor drainages which are admitt[illegible] means of little inlets. At the sixth mile it is crossed by the Ra[illegible] Torrent, passed over it by means of a masonry superpassage abou[illegible] feet in breadth. In the tenth mile the Puthri Torrent having a c[illegible]ment basin of about 80 square miles, or twice that of the Ranip[illegible] carried across the canal by a similar superpassage 296 feet in bre[illegible] The sudden flood discharges in these torrents are of great viol[illegible] the Puthri Torrent discharging as much as 15,000 second-feet and [illegible]ing a velocity of about 15 feet per second.

In the thirteenth mile the canal encounters the Rutmoo Torrent [illegible] a slope of 8 feet per mile and a catchment basin half as large [illegible] as that of the Puthri. This torrent is admitted into the canal [illegible] own level. In the side of the canal opposite to the inlet is an [illegible] masonry outlet dam or set of escape sluices. In the canal just [illegible] this level crossing is a regulating bridge by which the discha[illegible] the canal can be readily controlled. Thus in time of flood, by [illegible]ing the sluices in the outlet dam and adjusting those in the reg[illegible] so as to admit into the canal the volume of water required, the [illegible]mainder is discharged through the scouring sluices, whence [illegible]tinues in its course down the Rutmoo Torrent.

In the nineteenth mile, near Roorkee, the canal crosses the [illegible] River and Valley on an enormous masonry aqueduct. The [illegible] River in times of highest flood has a discharge of 35,000 second[illegible] and the fall of its bed is about 5 feet per mile. The total leng[illegible] the aqueduct is 920 feet. The banks of the canal on the up[illegible] side are revetted by means of masonry steps for a distance of [illegible] feet and on the downstream side for a distance of 2,722 feet. F[illegible] miles above the aqueduct and for a distance of half a mile b[illegible] the bed of the canal is raised on a high embankment. The gre[illegible] height of the canal bed above the country is 24 feet. The aque[illegible] proper consists of fifteen arches of 50 feet span each. In addit[illegible] these great works there are in the first 20 miles of the cana[illegible] masonry works for damming minor streams and a number of ma[illegible] falls.

Beyond Roorkee the main canal follows the high divide betwe[illegible] Ganges and the West Kali Nadi, and continues in general to follo[illegible] divide between the Ganges and the Jumna to Gopalpur, a sho[illegible]tance below Aligarh, where the main canal bifurcates (Pl. V.

GOPALPUR BIFURCATION, GANGES CANAL.

›rming the Cawnpur and Etawah branches. The former branch tails ıto the Ganges at Cawnpur and is 170 miles in length. The Etawah ranch is also 170 miles long and tails into the River Jumna near umerpur. The Vanupshahr branch leaves the main line at the ftieth mile and flows past the towns of Vanupshahr and Shahjahan-ır. It formerly terminated at mile 82½, emptying into the Ganges iver, but it is now continued to a point near Kesganj, where it tails ıto the Lower Ganges canal. The first main distributaries are taken om both sides of the canal a short distance below Roorkee. The ıture of the country offers abundant facilities for escapes from the ınals. Five are constructed on the main line, four on the Cawnpur ranch, and three on the Etawah branch, besides numerous small ›capes to the distributaries. These escapes will be described in ıother place. They are essential for the proper regulation of the ınal in the discharge of local drainage.

The maximum discharge of the canal is 7,782 second-feet. The verage annual rainfall over the area irrigated is 31.9 inches. The ıtire area commanded is 2,800,000 acres. The culturable area is 820,000 acres, and the area irrigated is 1,600,000 acres. The maxi-um area irrigated within any one year, including both spring and ıtumn irrigation, was 2,800,000 acres in 1883; the total length of ain canals is 419 miles. There are 2,552 miles of distributaries ıd 859 miles of drainage cuts and escapes, or a total of 3,830 miles. Of the total area irrigated in 1893, 96,543 acres, or 13.4 per cent of e whole, were double cropped and the duty performed by the canal r the autumn crop was 135 acres per second-foot on the discharge at e head, or 155 acres per second-foot on the discharge utilized. The tal capital outlay on these works to the end of the year 1893 was 0,127,000, and the working expenses for that year were $375,000. he working expenses per second-foot of discharge at the head were 03, or 52 cents per acre irrigated. The total water rate derived was .30 per acre irrigated, or $253 per second-foot of discharge at the head. mong the principal crops culivated in 1888 were 106,000 acres of ıgar cane, valued at $2,332,000; 228,300 acres of wheat, valued at ,275,000; 31,400 acres of rice; 80,000 acres of indigo, and a grand tal, including all other crops, of 601,900 acres, valued at $7,600,000. he net profits in 1888 were 5.4 per cent on the capital invested.

The number of days in the year when water was supplied for irriga-›n and the canal was in active operation was, in 1888, 275. In this ›ar a comparatively small supply of water was used, the mean supply ›ing only 2,400 second-feet.

LOWER GANGES CANAL, NORTHWEST PROVINCES.

As described in relating the history of the Ganges canal, the Lower anges canal was undertaken at the suggestion of Sir Arthur Cotton, 1868, after an investigation by Col. R. Strachey in 1865, as a means relief or improvement of the Ganges canal. It irrigates a part of

the Ganges-Jumna interfluve that was originally intended should be commanded by the Ganges canal proper. The work comprises a masonry diversion weir at Narora, about 3 miles below the railway crossing at Rajghat. It relieves the Ganges canal of 128 miles of the Cawnpur branch and 130 miles of the Etawah branch, and as originally projected was intended to carry 6,500 second-feet in the spring season and 3,270 second-feet in the autumn season. In 1871 the works were commenced, but were delayed awaiting a revised estimate submitted in 1876, when the work was finally commenced. It is now considered as a work separate from the Ganges canal.

The weir is a substantial one, resting on masonry wells, usually 2[illegible] feet deep; the front and rear curtain walls rest on smaller wells. The weir is 3,800 feet long and is 10 by 10 feet in cross section, having a vertical overfall to a paved floor. It is constructed chiefly of brick. There are 42 weir scouring sluices opposite the canal head, each 7½ feet wide. The regulator at the canal head is constructed of masonry and has 30 openings each 7 feet wide. The weir crest is 7½ feet above the sill of the canal and this can be raised to 10 feet by means of shutters. For the first 26 miles of main canal the bed is 216 feet wide; the full supply depth is 10 feet and the slope one-tenth of a foot in 1,000.

In the first portion of its line the canal is compelled to follow the river bottom for some distance before its grade enables it to surmount the banks and reach the summit of the interfluve. In this low reach the canal is threatened constantly by the encroachments of the river and extensive river-training works are necessary to preserve its integrity. These extend for a distance of 4 miles above the canal head and 15 miles below, and consist chiefly of long earthen groins or embankments, sometimes 2½ miles in length, projecting into the stream at right angles to its course and protected at the end by loose rock noses. The general slope of the Ganges River and of the country at this point is about 1½ feet per mile and the greatest flood the river has discharged is 350,000 second-feet. Its minimum discharge has been as low as [illegible] second-feet. The velocity in the canal is very low, being but 2 feet per second, and as a result much silt is deposited and the growth of weeds is excessive. The maximum discharge of the canal as now constructed is 5,100 feet. The average annual rainfall on irrigable land is 34.5 inches; the gross area commanded is 4,387,200 acres, and the culturable area 2,435,400 acres, and 1,187,326 acres will be irrigable when the project is completed, though at present but 833,951 acres are irrigable. The total length of the main canals is 557 miles. There are 2,159 miles of distributaries and the total length, including escapes and drainage cuts, amounts to 3,123 miles.

The capital outlay to the end of 1893 was $12,073,000. The net receipts in that year amounted to $114,000, a little less than 1 per cent net profit on the capital invested. The area irrigated in 1888 during the autumn crop was 327,000 acres, of which 184,000 acres were irrigated

ated by wells. Twenty-three per cent of the whole was double-
opped, and in the autumn season 1,765 second-feet of water were
tilized, the duty on which was 185 acres per second-foot. The cost of
aintenance of the distributaries was $13 per mile. There were 222
res irrigated per mile of distributaries at a cost of a little less than
a hundred acres, and the average depth of water used in these was
1 feet. The most notable works on this canal will be described in
eir proper place. They are the training works, the weir and other
ad works, and the great aqueduct at Nadrai, by which the canal is
rried over the Kali Nadi Torrent.

AGRA CANAL, NORTHWEST PROVINCES.

The Agra was the third of the great perennial canals of the North-
est Provinces visited by me. This canal was contemplated when
e question of the remodeling of the Ganges canal was being agi-
ted in 1864. It was then pointed out that water might be drawn
om the River Jumna below Delhi to supplement the irrigation of the
anges-Jumna bench lands. The idea was further discussed in 1866.
1867 projects were submitted and in 1868 the works were sanctioned
r the purpose of famine relief. The works as eventually sanctioned
1872 correspond closely to the present completed Agra canal project.
was formally opened in March, 1874. In 1875 it was found that the
iginal weir was insufficient. The great flood of that year had seri-
sly injured the scouring sluices and the works were then recon-
ucted. The head works of the canal are situated at Okhla on the
ver Jumna, 10 miles below Delhi, and consist of a weir about 2,573
et in length at a point where the river is 4,400 feet wide. The left
ng of the weir rests on an island, whence it is continued as an earth
ibankment 20 feet wide on top. This weir rests on wells sunk in
e deep sands of the river bed. On the upstream side it has a slope
about 1 in 4, the downstream slope being very long, as flat perhaps
1 in 20. As originally constructed in 1870, this weir was not more
an 130 feet in width from toe to heel, but after being injured by
ccessive floods it was carried out and added to until its width is now
er 240 feet. The scouring sluices are 139 feet long at the end of
e weir, and are composed of 16 gateways of 16 feet each. The regu-
ing sluices consist of 12 openings, each 6 feet wide and 10 feet
gh, to the springing of the arches, and are so located as to avoid the
posit of silt at the canal head. The water of the river is deflected
ward the right bank against the regulators by a series of groynes
d river-training works. There are about 8 miles of embankment
ong the river margin to protect the low land from inundation and to
event the flank wall of the weir from being turned.

From Okhla the canal follows the high land between the Khari Nadi
d the Jumna, and its course throughout is fairly parallel to that of
e Jumna, about 3 to 12 miles from its right bank. It finally tails

into the Ootunghun River about 20 miles below Agra. The ma branches connect the canal with Muttra and Agra.

The source of supply is from the Jumna River. The high recorded flood was of long duration and rose 50 feet above low-wate level, the velocity then being 12 feet per second and the discha about 1,300,000 second-feet. The supply of the Jumna having fall occasionally below 800 second-feet it is supplemented by a cut fr the Hindun River, which discharges into the Jumna just above th diversion weir, and is capable of supplying 300 additional second-fe The grade of the canal from the head to the thirty-second mile is inches per mile. There is a fall of 5.75 feet, beyond which the gra ent is increased to 1 foot per mile to the end. In the first portion the canal the bed width is 70 feet per mile and the depth from 6 to feet, while the velocity is from 2 to 2½ feet per second. Below the fall the bed width is decreased to 60 feet and the maximum depth 7 feet. Beyond the one-hundredth mile the velocity is from 1½ to feet per second, the bed width 20 feet, depth 5 feet, and the discha about 200 second-feet.

The Hindun cut is 9 miles in length and 24 feet wide at the bot with a mean depth of 5½ feet. The works of especial interest on canal beyond those of the weir and head-works proper are an inter ing superpassage made of boiler iron situated at about the eighth m and some drainage settling basins constructed as reservoirs for collection and concentration of numerous small drainage chann The total length of main canal as completed is 134 miles and the 558 miles of distributaries. Its total maximum discharge is second-feet. The average rainfall on its irrigated lands is 27 in the gross area commanded 768,000 acres, nearly all of which is cu able, while the area irrigated is 240,000 acres. The total capital lay to the end of 1888 was $3,010,000, and the net revenue va between 3 and 4½ per cent per annum.

Of the total area irrigated in 1888, 11 per cent was by means of w The water rate charged was $233 per second-foot of water utilized $1,120 per mile of canal; the cost of maintenance was $11.50 per and 74 acres were irrigated per linear mile at a cost of $5.15 pe acres. The average depth of water used in the autumn season 1.2 feet. The principal crops cultivated were much the same as cited for the Ganges canal, the cultivation of indigo heading th with an acreage of 28,500 acres, cotton being second with 22,000 a and pease next. The area of wheat cultivated was 14,500 acres the total value of all crops $1,090,000.

The canals of the Duns are usually small and have been constru in a mountainous country at a rate of expenditure that would be sidered quite unwarranted and prohibitive in the United St There are five principal canals in the Duns, ranging from 11 to 1 in length and aggregating 67 miles. They have annually retu

over 6 per cent interest. These canals command 5,000 acres, more or less, each. The works are simple in character, but owing to the great rainfall expensive masonry aqueducts crossing high valleys and broad torrents are numerous, and in many cases the canal channels are constructed wholly of masonry for long distances. The total maximum discharge of these canals is 240 second-feet, and the precipitation on the irrigated lands averages 100 inches. They irrigate a gross area of 25,000 acres. The capital outlay on their construction was $1,070,000, and while the average interest received is over 6½ per cent, on some of them it exceeds 12 per cent. The crops cultivated are similar to those produced elsewhere in the Northwest Provinces, but wheat and rice far exceed in amount all other crops together. In 1888 there were 15,400 acres of food crops grown, nearly four-fifths of which consisted of wheat and rice.

SIRHIND CANAL, PUNJAB.

Of the important perennial canals in the Punjab, the Sirhind far exceeds all others in matters of engineering interest, as it is the most recent and modern in construction, besides being one of the greatest. Of the other important canals of the Punjab, the principal are the Bari Doab and the Western Jumna, two of the most profitable canals in northern India. The Sidhnai canal, which has only recently been opened, was, as originally constructed, an inundation canal and is still partially operated as such. Though I saw little of the Sirhind or Sidhnai canals, a brief description of each will be given, as they represent some of the latest developments of irrigation as practiced in India.

In the time of the Emperor Feroze attempts were made to utilize the waters of the Sutlej River for irrigation. These attempts were, however, of little moment. Maj. W. E. Baker first showed the practicability of a canal from the Sutlej to irrigate what was known as the "Hard Desert" in the districts of Hissar and Bhuttiana. The few wells there were so deep that irrigation from them was impossible, while the water was impure and brackish. The population was scanty and lawless, their chief occupation being cattle raising. The question was not how to improve agriculture, but how to create it.

Major Baker proposed heading the canal above Rupar, utilizing the line of the old canal of Mohammed Shah, but Col. Baird Smith, who examined this project, reported that "the occupation and repair of old canals was the most fruitful source of evil in the existence of canals," and he suggested a new alignment.[a] Major Baker's investigations were carried out in 1840, and the project then submitted was very similar to that of the now completed Sirhind canal. In 1860, at the request of the Maharajah of Pattiala, who offered to defray the expenses, the whole question was investigated by the British officers.

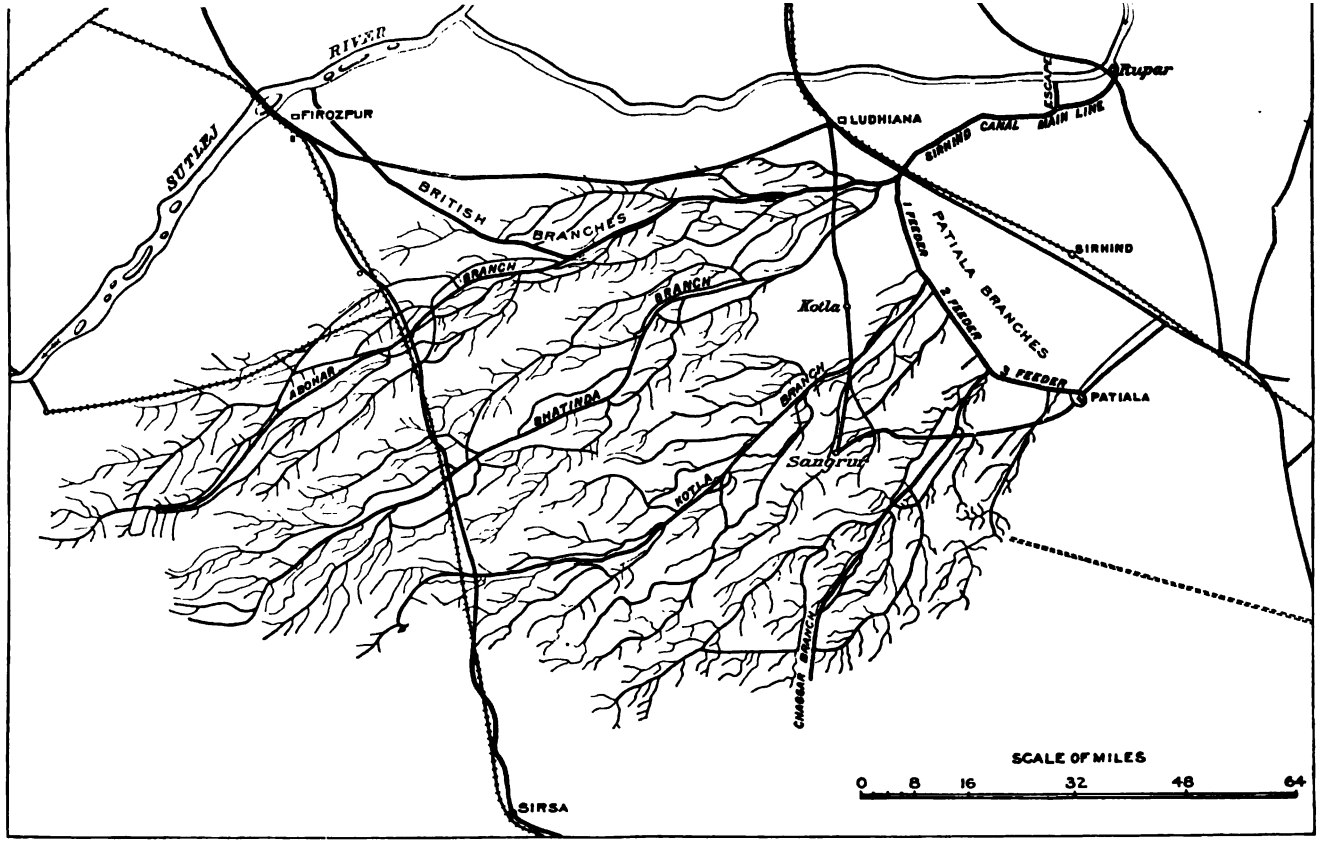
[a] Smith, Col. Baird, Irrigation in Italy, London, 1856, vol. 1, p. 256.

A project was submitted in 1862, and in 1865 the British Government decided that any canal constructed here should be devised irrespective of boundaries of British or native States. In 1868 the project was vigorously pushed, the size of the main channel was increased, and the head-works were moved 15 miles down the river to a point very near Rupar, and in 1869 the works were actively commenced.

This project (Pl. VIII) comprises a main canal from the Sutlej supplied by a masonry diversion wier. The length of this main channel is 41 miles. Of the branches, the eastern ones irrigate native State lands and are called the Pattiala branches; the remaining or western branches are known as the British branches. The heaviest portion of the work is in the first 10 miles, where the line crosses many hill torrents draining into the Sutlej. The head-works are, like those of the Ganges and Jumna rivers, situated at the point where the river emerges from the hills through a rocky bowlder channel, and where the general fall of the country is over 8 feet per mile. The maximum depth of the cutting through the spur at the head near the town of Rupar is 45 feet, and the average depth of cutting in the first 7 miles is 28 feet. The drainage in places is passed over the canal by masonry superpassages, while one torrent is diverted into the river by a cut terminating above the head-works. At the forty-first mile the main canal ends and the two branches diverge. Three miles below the bifurcation the British branch is again divided into the Bhatinda branch, 100 miles long, and the Ubohar branch, 125 miles long. On the Pattiala side the main feeder is divided into three sections by the diversion of the Kotla, Gagger, and Choa branches, respectively 15, 56, and 25 miles in length. The end of the feeder is the junction of the Choa and Pattiala branches, the latter being 6 miles long and terminating at Pattiala.

The principal works of interest on the line of the Sirhind canal are the head-works at Rupar, the superpassage crossing the Siswan Torrent, which in time of flood discharges 20,000 second-feet, and the superpassage across the Budki Torrent, which in time of flood discharges 30,000 second-feet. The siphon for a drainage crossing of Hurron Torrent, though small, is likewise deserving of particular mention in its place.

The water supply of the Sirhind canal is less than was anticipated. The least discharge of the river ever recorded was 2,818 second-feet, while the average minimum discharge is 5,150 second-feet. The maximum discharge of the canal as designed is 7,849 second-feet, and the maximum flood discharge of the river has been as great as 1[illegible] second-feet. The rainfall over the irrigable area varies between [illegible] and 35 inches per annum, and during the autumn crop is from 1[illegible] inches. The gross area commanded by the canal is 4,558,602 acres, which 1,170,000 acres are irrigable. During the autumn crop of 1[illegible] only 406,805 acres were irrigated, of which 161,967 acres were double cropped.



SIRHIND CANAL SYSTEM.

The total length of main canals is 41 miles and the total length of ain branches 538 miles, while there are 4,636 miles of principal dis- butaries. The total outlay on this canal to the end of 1901 was 9,663,000, and since the canals were opened the net annual revenue s constantly increased, until in 1901 it amounted to 4.7 per cent. the year under consideration the duty per second-foot in the autumn ason on the supply entering the canal head was 108 acres, or $113, d on the supply utilized it was 110 acres, or $121. The average ater rate per acre irrigated was 95 cents, the working expenses being cents per acre, and the cost of establishment was 15 cents.

CHENAB, BARI DOAB, AND WESTERN JUMNA CANALS, PUNJAB.

As before stated, these three canals are among the oldest and best ying of their kind in India. In 1351 Feroze Shah constructed the st channel where the Western Jumna canal now exists, and at fferent periods up to 1817 the works were reconstructed and utilized. 1817 Captain Blaine prepared to restore them. The supply of the estern Jumna is derived from the Jumna River at a point where it aves the Sewalik Hills, where the fall is great and the bed com- sed of shingle and bowlders. On the opposite bank the Eastern mna heads at nearly the same place. In 1870 permanent head- orks, distributive and drainage works, were constructed to replace e old ones, and a little later the main canal was almost entirely aligned. At the end of 1878 the total receipts since the works were ken in hand by the government had exceeded the working expenses d interest on the capital by $12,500,000, or about four times the st cost of the work. The total length of the main canal and anches in 1901 is 391 miles, and there are 2,210 miles of distributa- es. The area irrigated is 870,500 acres and the maximum discharge the canal is 6,350 second-feet. The total expenditure on this work the end of 1901 was $10,730,000, and this earned revenue of 9.1 per nt. The gross receipts in that year were $835,000, and the gross tlay $325,000, the net revenue being $510,000.

The Bari Doab canal derives its source of supply from the Ravi iver, and commands 1,641,660 acres of land between the Ravi and ias rivers. In 1633 the Shah Jehan construct d the first canal in this eighborhood. The project for the new canal under British rule was rst reported on in 1850, when the works were commenced. In 1856 ey were revised, and water was admitted to some portions of the nals in 1859. In 1874 the works were decided upon as now con- ructed, and were estimated to produce a profit of 8.8 per cent. ecently a considerable amount has been expended in the construc- on and improvement of falls and rapids. The total outlay to the nd of 1901 was $14,115,000 and the interest in that year was 12.9 per ent on the capital outlay. The maximum discharge of the canal is ,500 second-feet, and the area irrigated 849,074 acres. There are 369 iles of main canals and branches and 2,725 miles of distributaries.

The Chenab Canal is diverted from the river of that name, and commands 2,910,470 acres. It consists of 430 miles of main and branch canals and 2,059 miles of distributaries. To the end of 1901 its cost was $11,111,000, when it earned 14 per cent interest on that outlay. In the same year it irrigated 1,384,046 acres on a maximum discharge of 10,474 second-feet.

SIDHNAI CANAL, PUNJAB.

Estimates for a permanent inundation canal from the reach of the Ravi River were submitted in 1875 by Mr. E. C. Palmer. In this project the head of the canal was located at the top of the straight reach called the Sidhnai. Owing to bad alignment (as Mr. Palmer's project followed a low depression for many miles), the position of the head-works was abandoned, and a new site selected at Tatyraj, where the section of the river is 770 feet across and the banks consist of stiff brown clay.

The maximum discharge of the river is 18,000 second-feet, and is not likely to be exceeded. Gage records show that all idea of the construction of a perennial canal from this part of the river must be abandoned, as twice since 1875 the Ravi has been absolutely without flow during the cold season. As constructed, the only masonry works of the canal besides the head-works are the bridges and the heads of distributary channels. The area commanded is about 381,000 acres. Of this the present works provide for the irrigation of 194,900 acres. The duty was assumed to be 60 acres per second-foot, and the discharge of the canal was placed at 800 second-feet. The rainfall of the irrigated area has averaged 5.9 inches per annum. When the canal project was reported on in 1883 most of the country was covered with jungle to within about 3 miles of the river. This jungle consisted of coarse grass, brush, and tamarisk. The crops now grown on this land during the summer season are sugar cane, indigo, rice, cotton, and millet, and during the autumn season wheat, barley, turnips, and lentils.

On the line of the canal no drainage or protective works are required except one or two very insignificant ones. At first the canal was only excavated to half width, but all the masonry works were constructed of full width. As finally aligned the canal leaves the Ravi River at right angles and runs straight for 2,000 feet, where a long curve commences, ending at 3½ miles. It then keeps along the divide to Chiparata, whence it runs mainly in the bed of the old river Ravi. There are four main distributaries and six minor ones.

The head-works consist of a regulator with 8 sluice openings of [illegible] feet each. The curtain walls of the regulator and river banks are founded on wells 10 feet below the present river bed. Wells were adopted in preference to concrete, though they are more expensive and it was not certain that the latter could be put in 10 feet below [illegible]

bed. The weir consists of a wall 750 feet long, founded on concrete in the center and on wells for 20 feet from each bank.

The maximum discharge from the canal is 2,452 second-feet, the bed width of the main canal is 80 feet, the depth of water 5 feet, and the velocity of flow 1.85 second-feet. The discharge of the river varies between nothing at extreme low water and 18,000 second-feet at maximum flood.

The total cost of this work to the end of 1901 was $620,000. The net receipts for the same year amounted to $34,500, or 5.8 per cent on the capital invested. The water rate charged per acre irrigated during the autumn crop was 62 cents and the duty during the same season was 85 acres or $57.

THE SOANE CANALS.

Like the Sirhind canal in the Punjab, the Soane system in Bengal may be taken as an example of the most recent practice in the construction of a perennial canal system. The Soane canals are included in one system heading at a common point and having a common diversion weir. They consist of two main lines, one flowing from each bank of the Soane River. The Soane River is a tributary of the Ganges, rising in the central plateau of India and having a course of about 350 miles through the high country. Near Rhota it breaks through the hills, which at this point are 2,100 feet above the sea, whence it flows northeasterly for 75 miles through the Gangetan Plain to its junction with the Ganges near Arrah. In the plain it flows through the districts of Shahabad on the left or west bank and Patna and Gaya on the east bank. These are among the most fertile and highly cultivated districts in Bengal, densely populated and studded with ancient cities. The successful operation of the Soane canals is largely due to the acreage which is cultivated during the autumn season.

The works of the Soane canal were first undertaken by the East India Irrigation Company, but given over to the Government when scarcely any work had been done. The scheme was originally proposed in 1853 by Lieut. C. H. Dickens. A plan to utilize the larger portion of the volume of the Soane was, however, amplified by the same officer in 1861. In 1862 the secretary of state approved of the project, and after discussion by Sir A. Cotton and Colonel Rundall it was forwarded for the approval of the Government in 1864. In addition to the features now existing it was proposed in the original project to construct reservoirs in the hills south of Rajmahal to supplement the available discharge of the river. This part of the scheme was considered too expensive, however, and the plans were changed. In 1869 the work was undertaken by the Government. It was estimated to give a net profit of 12½ per cent on the outlay. In 1871 it was decided to reconstruct the slope of the canal, as the supply of water was not as great as had been anticipated.

The catchment basin of the Soane above Dehree, where the head works are situated, is about 22,000 square miles in area, and in flood the river discharges 750,000 second-feet, though the maximum flood provided for is 1,250,000. For about 40 miles below the diversion weir the floods seldom overtop the river banks, but below that point to its junction with the Ganges it is almost deltaic in character, considerable overflow taking place. To about this point the canal follows the bank of the river rather closely, after which it diverges and follows the high ridge between the Soane and Ganges.

The diversion weir across the Soane is at Dehree, a point 25 miles below where the river leaves the Kymore Hills, and is the longest weir in one unbroken length of masonry that has ever been constructed, being 2⅓ miles long and 8 feet high. In high flood the river rises [illegible] feet above the crest of the weir. The main western canal (Pl. IX

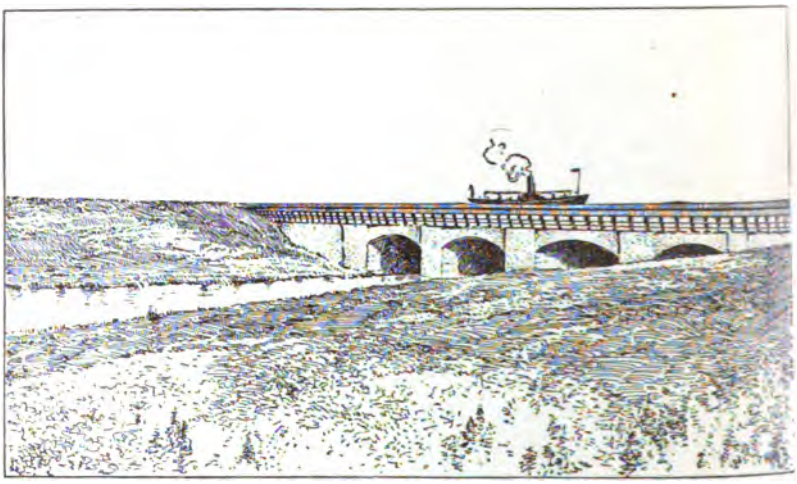
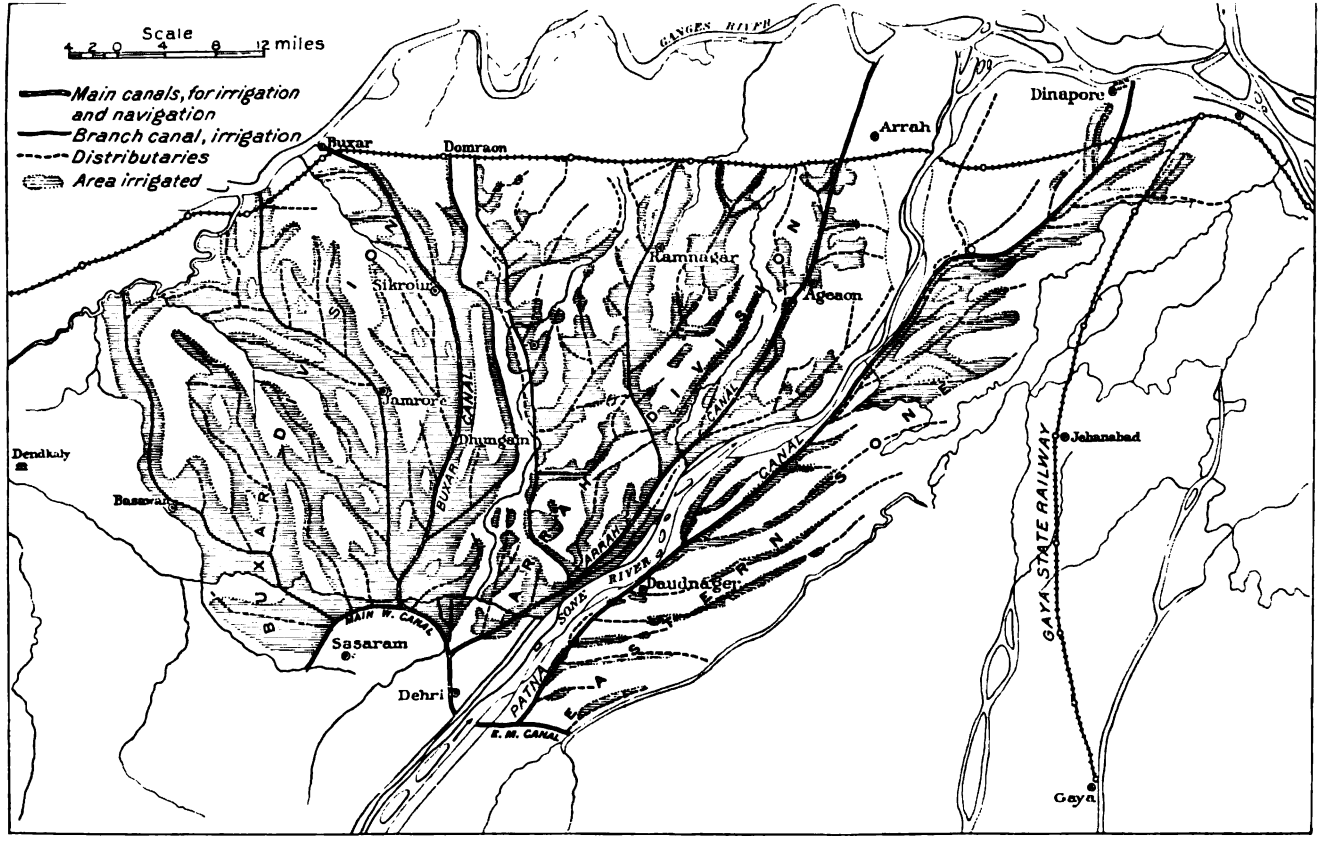


FIG. 8.—Thora Nulla aqueduct, Soane canal.

takes off from the weir on the west bank where it encounters a rather deep cut. It crosses the Kao Torrent by a large siphon aqueduct at the ninth mile and similar drainage channels in the seventeenth and twenty-first miles. The Arrah canal leaves the main western at the fifth mile and follows the bank of the Soane to the thirty-third mile where it leaves it and passes close to the town from which it takes its name, tailing into the Ganges. On this line are 13 locks with an aggregate fall of 161 feet. The Buxar canal leaves the main western at the twelfth mile and is almost straight from that point to the Ganges at Buxar. The total fall in this line is 153.75 feet, and in the twenty-ninth mile the canal crosses the Thora Torrent (fig. 8) on an aqueduct with 4 arches, each of 30-foot span. The other main canal of this system, the main eastern, takes off from the Soane weir on the eastern bank opposite to Dehree and is 7 miles long, its terminal



SOANE CANAL SYSTEM, BENGAL.

being at Poon Poon Torrent. The Patna canal leaves the main eastern at the fourth mile, and, after following the river bank for 60 miles, is diverted to the ridge and tails into the Ganges near Patna. It was estimated by F. T. Haig, R. E., when chief engineer, that these canals would pay both interest and working expenses on the outlay until 1887, when it was expected that they would return a net profit of 4½ per cent.

The important feature of the head-works is the mode of construction of the weir, the automatic action of the scouring sluices, and the arrangement of regulating gates. These are elsewhere described in detail in connection with the subject of automatic scouring sluices, on pages 121–122, 127–128. The weir and principal works were designed by H. C. Levinge, chief engineer of the East India Irrigation Company.

The minimum discharge of the Soane River at Dehree is 5,260 second-feet in summer and 1,870 second-feet in autumn. The maximum discharge of the canals is 6,350 second-feet, of which the main eastern canals discharge 1,850 and the main western series 4,500 second-feet. The average rainfall upon the area irrigated is 41 inches. The gross area commanded by the entire system is 1,733,509 acres, of which 1,016,400 acres are irrigated. There are 367 miles of main canals and 1,217 miles of distributaries. The average discharge utilized in the autumn of 1901 was 3,300 second-feet, and the duty performed during the autumn was 110 acres per second-foot of the supply utilized. The water rate per acre was 85 cents. The total length of village channels or minor canals is 1,525 miles; the total number of outlets for distribution of water is 6,000, the area irrigated per outlet being 93 acres.

In the Arrah division, Mr. W. A. Inglis, the executive engineer, calculated the supply of water spread over the country was equal to an effective rainfall of 5.7 inches. On the assumption that one watering of 6 inches in depth is given every fifteen days, 1 second-foot of discharge should irrigate 60 acres if the outlet were constantly open, or 40 acres if the discharge outlet were open for only ten out of fifteen days. The cost of repairs to the head-works in 1890 was about $16,000 per annum and the cost of maintenance exclusive of head-works about $81,000. The charges for silt clearances amount to $30,000 per annum, the total amount of clearances being 10,850,000 cubic feet and the rate about $3 per 1,000 cubic feet. The silt clearances were made by means of large steam dredges. The total cost for weed clearance was $1,600 in 1888, and the mileage rate or cost of repairs varied from $30 per mile on distributaries to $65 per mile on smaller branches, $211 on larger branches, and $2,800 on the main western canal.

The following is a statement of traffic on these canals for the year 1888. There were 218 miles of canal open for navigation. The toll-

age receipts from private boats amounted to $12,000; on government boats $1,400, and on rafts $3,500. These with minor items make the total receipts from tollage $18,600. The maintenance charges, including navigation establishment, were $11,800 and the net revenue from navigation was $6,800. The total number of cargo boats was 4,547; of passenger boats 530. The total tonnage of these boats for cargo traffic was 71,243 long tons and for passenger traffic 12,[illegible] long tons, and the total ton-mileage was 4,635,000 miles. The estimated value of the cargoes was $1,785,000 and the passengers carried numbered 46,170. There were estimated to be 3,089,000 cubic feet of rafts, valued at $107,000. The tollage receipts per ton-mile on boats was 3 mills, and tollage on rafts per hundred cubic feet was 11 cents.

The total outlay on the Soane system to the end of 1901 was $17,558,000 and the revenue in 1901 was $175,000. The gross receipts were $370,000. There was a net revenue, after deducting all working expenses, of $162,000, or 1.8 per cent, on the capital outlay.

CROSS SECTION, SLOPE, AND ALIGNMENT.

In designing a canal system the Indian engineer, having decided the location of the head-works and ascertained the source of supply and the area and location of irrigable lands to be served, next considers the proportion of width to depth of his channel, the cross-section area being fixed by the supply of water to be discharged at any point. On the Western Jumna canal the proportion of depth to width is that which the Jumna River has in the course of years formed for itself, found by trial to be about 1 on 13. On the Bari Doab the proportion fixed in construction was 1 on 15, and on the Sirhind 1 on 14. In the case of the Nira canal, which is nonnavigable and of a smaller capacity than those just described, the proportion is much less, the depth being 7½ feet and the bottom width 23 feet. On the Soane the main western line has a depth of 10 feet and a bottom width of 100 feet, a proportion of 1 on 11. The Betwa, which, like the Nira, is nonnavigable, is relatively deeper than the larger canals, being 5 feet deep, a 15-foot bed width on some branches, and on others 6 feet deep, a 30-foot bed width. The proportion first given is such as will apply only to canals so great as to correspond in their general characteristics to large rivers.

The side slopes of the canal (fig. 9) are generally arranged according to the facilities for excavation, and are such that the ground will stand at a natural angle. In the soils in which the canals are generally excavated in Bombay the side slopes are usually 1 on 1½ on the inside and 1 on 2 on the outside. The matter of fixing the cross section has been a difficult one to solve on account of the conflicting conditions of the supply of water required and velocity permissible. This is fixed

the liability to growth of weeds, the deposit of silt, or the destruc-
n of the banks by erosion.

Iaving determined the quantity of water, fixed the proportion of
lth to depth, and ascertained a maximum for both, the slope of the
l becomes one of the most important remaining problems in the
ign of the canal. If the slope be too great, the bed of the canal
l its sides will be eroded and the integrity of the masonry and other
uctures endangered. If it be too small, a larger section of channel
l be required to discharge a given quantity of water, and additional
rks, as falls, may be necessary to overcome the excess of surface
pe in the country. The growth of weeds and aquatic plants and
deposit of silt will become a troublesome evil. As it is difficult to
oid both extremes, a compromise has generally to be made. It is,
haps, well to err on the safe side and give to the bed the greatest

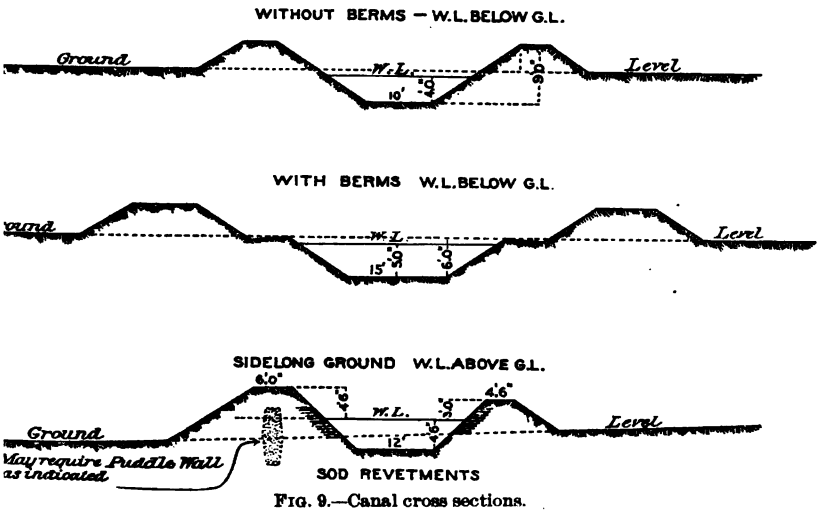


FIG. 9.—Canal cross sections.

ope apparently desirable. If this slope should prove to be too great
the fall of the country too rapid, the difficulty may be remedied by
troducing falls and rapids in the channel to diminish its general
ope and concentrate the loss of grade in a few places. In different
ils and in different canals the velocity given for the prevention of
e growth of weeds and the deposit of silt differs largely, but it has
een found generally that the minimum velocity is about 1½ feet per
econd. According to American experience this is too low, as we
sually consider that 2½ or 3½ feet per second is the minimum. In
ndia the maximum for ordinary soils rarely exceeds 4 feet per second.
n America it is often much higher.

One of the greatest difficulties encountered in India in determining
he velocity, slope, and cross section to be given to a canal has been
he introduction of navigative works. These are generally antago-

nistic to the requirements for irrigation purposes only. The vel of the current in navigable canals must be low in order to per traffic in both directions. In the Ganges canal, with a bottom wi of 170 feet and a 7-foot supply, a slope of 14 inches per mile has been given in the sandy soil of the upper reaches, and the resultant ve ity is such that the current has just ceased to cut the banks and deposit silt. In the first portion of the canal where the bed is gravel and bowlders the fall is 24 inches per mile. From there on slope of from 15 to 17 inches has been found to be too great, the having done much damage to the banks. The larger portion of reach of 20 miles from Hardwar to Roorkee is extensively ripra now and the engineers are continually adding a lining of bowlders the bed and sides of the canal.

The velocity of 3 feet per second, which was originally given Soane canal, caused much damage by erosion and had to be reme Colonel Anderson, R. E., made some interesting remarks on this ject in the Roorkee Manual, among which were the following:

> Where the fall of the country is tolerably uniform the slope of the bed main channel must be less than that of the branches. This, again, must than that of the distributaries and minors, the object being to secure as f possible, a uniform velocity, so that the matter carried in suspension may ried on from the head and deposited over the irrigated lands. At the he canal it is sometimes desirable to reduce the width in order that with an in depth the velocity may be the same as that in the channel lower down.

He says that the accumulation of silt in the main channels is ous impediment to obtaining a supply of water until the crop mature, and their clearances are enormously expensive. If th can not be carried to the fields, it is a step in advance to preve accumulation in the main channel. It is easier to clear out the branches without cutting off the supply from the main river. Es are introduced at intervals in all canals for the control of th charge of water and to facilitate silt clearances and as a preve of its deposit.

The following interesting observations were made by Major in his report on the Ganges canal relative to velocities of cu Where the current seemed to be perfectly adjusted to a light soil the velocity of the surface was found to be from 2.3 to 2.4 fe second and the mean velocities, using 0.80 as a coefficient, were to be 1.85 to 1.93 feet per second. In one place, where silt was constantly deposited, the mean velocities were from 2 to 2.3 fe second. On the same canal in very sandy soil, with nearly supply of water, the maximum surface velocity was found to be and the mean velocity 2.49 feet per second. In one of the di taries, where the soil is sandy with a fair proportion of clay, the velocity was 1.93. Here silt was deposited but no weeds grew the Western Jumna canal Colonel Dyer, R. E., found that s

posited with mean velocities of from 2 to 2¼ feet, and in sandy soil · feet per second was the highest mean velocity for noncutting. ckson's and Neville's formulae are those most usually employed in e determination of velocities and corresponding cross sections. In signing the proportion of excavation to embankment and the width berm, several interesting but involved formulae are employed by e Indian engineers, of little service, however, as guides to the signers of American canals.

Great care and judgment must be exercised in the alignment of an igation canal. Any change of direction causes a loss of velocity, d the slope should be changed if it is essential to introduce a curve. e water drawn into branches and distributaries loses velocity in ssing through the head-sluices unless they possess the full water-y of the channel, and due allowance should be made for this by ding to the slopes at the heads of branches. The Indian engineers ve always deemed it essential in designing their canal systems to ke a thorough and detailed survey of the country to be irrigated, that the most perfect alignment and command of the lands can be tained. Trial level lines and careful transit surveys are run, after ough survey has been made, and the whole is shown on a large scale ntour map. A complete delineation of the drainage of the country one of the primary objects, as is also the direction of the drainage tlets and the interfluves. The nearer the line of the canal approxi-ates to the summit of the watershed the better will be the align-ent, as the interference with the surface drainage of the country ll then be the least possible. In encountering cross drainage pro-sion must be found for its safe passage, and unless the streams are ry small they should never be permitted to enter the channel. The nal should always be made to tail into some drainage line or river, that the surplus may not be lost, and in order to insure a sufficient our it is deemed advisable to increase the velocity at the end. hen practicable all embankments are formed by ramming the soil thin layers. Where the channel runs through sandy soil the beds d banks should be covered by an impervious puddle.

Great care has been used to fix the permanency of all transit points d bench marks, etc., on the surveyed lines of canals in India. On e outer edge of the berm are placed masonry mileposts, with smaller asonry pillars every one-fourth mile, while on the inside white-ashed stones are laid into the ground every 100 feet. At frequent tervals large substantial masonry benches are established.

HEAD-WORKS.

The head-works of canals are usually located at the points where e rivers emerge from the hills, in order to obtain a sufficient com-and of land and allow the canals to reach the summits of the inter-uves with the shortest possible length of diversion line. In India,

owing to the great volume of flood water required to be passed the diversion weir, it is necessary to have an extremely wide way, and it is usual to locate the weir in a relatively wide portion the channel. If the only consideration in the location and construction of a weir was the raising of the water of the river to the level the canal bed, in order to obtain the shortest possible diversion, the most favorable location would be in the lower courses of the river where the fall is gradual and the banks shallow. Such an obstruction of the bed in these localities would, however, raise the surface of water in freshets, rendering necessary the construction of and embankments and other protective works, and would be extremely objectionable. A rock bed, though a great advantage and always be preferred, is not considered an indispensable requisite in structing weirs.

Several great Indian weirs have been thrown across rivers whose beds consist entirely of pure sand, reaching far below the foundations. In such constructions the chief requirement is a strong apron beneath the weir to break the fall of the water and prevent the foundations from being undermined. Prof. George Davidson says:

> In order to reduce the first cost of construction it has become a custom America to build bridges and dams across streams at the narrowest point available, or to contract the streams for that purpose. This frequently involves difficulty to the engineer in laying the piers and abutments, and also brings additional danger by adding to the scouring effect of the water on a scouring channel; it also produces the evil effects by the formation of shoals in the scouring-out channel. The proper location for such works, especially rivers with unstable banks, is in the broad reaches of the stream, where depth of the water is less and where a bar has been already formed across river by natural causes.[a]

A dam across a river is analogous to a bar, and should be located and treated as such. If this is placed at the broadest part of stream the cost of construction may be increased, but not necessarily. Instances of the location of weirs in the broadest reaches rivers may be cited in the case of nearly every weir constructed India. The weir at the head of the Ganges canal occupies the width of the channel; those of the Bari Doab and of the Sirhind thrown across at points where the width of the river is an average. The weir at Okhla, at the head of the Agra canal, is also constructed in a broad reach.

The head-works of Indian canals consist essentially of the across the river by which the level of the water is raised and is checked; of a set of scouring sluices placed in the weir at the adjacent to the canal head, the object being to create a constant past this head, thus preventing and carrying off any excessive deposits of silt, keeping as they do the course of the main channel of the close to the canal head; and, lastly, of a regulator across the

[a] Davidson, Prof. George, Irrigation Works of India: U. S. Senate Doc. No. 94, First Congress, Washington, D. C., 1875.

canal channel, by which the proper quantity of water is admitted . In a few cases, as those of the Ganges and Jumna canals, where canal is taken from a branch of the river, a permanent dam is wn across this channel only, the water being diverted to it by ns of the river-training works.

WEIRS.

ie weirs employed are of various kinds, but are always con- cted substantially of masonry and are well founded. They may on solid rock foundations and be nearly vertical with an over- onto a rock bed, or flat and low, founded on wells in sand, with rtical overfall onto an apron of masonry; or they may be similar ie latter with the exception that instead of the vertical overfall downstream slope may be constructed of loose-packed rock on a ; slope of, say, 1 on 15 on 20. Only rarely are porary weirs constructed ply of loose bowlders. two great classes of s are solid weirs, such hose above indicated, or n weirs, in which the ob- ction is temporary, as dles or removable sluice es.

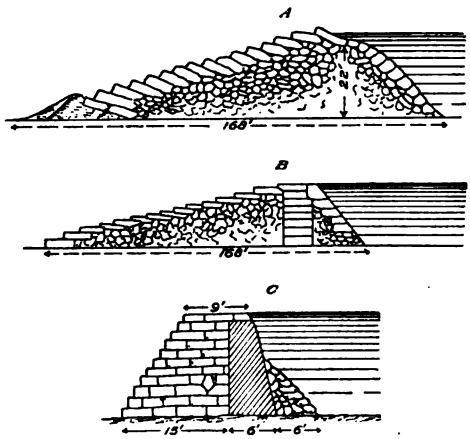


FIG. 10.—Three ancient weirs.

he antiquity of weirs very remote. The first at weir, that at Tulkad, the river Cauveri, is said have been constructed one Madwa Rou, A. D. . Many others are said to belong to the sixteenth century, while ers are of intermediate dates. The new works of the Indian ives are of minor importance, with the exception of the Poorniah nnel, constructed in the early part of this century to lead the red waters of the Cauveri River to Misau. Rough stone weirs st at the heads of most of the channels in Misau. These raise the ter level to the required height, the lowest being 7 feet and the hest 25 feet. The canals are for the most part supplied with ulating sluices at their heads and with escapes for getting rid of od waters.

The accompanying illustration (fig. 10, *A*) shows the section of a tive weir constructed early in the present century, the breadth of ich, parallel to the course of the stream, was 168 feet. This weir nsisted of a mass of rubble and large stone, the front face formed stones 1½ by 1 foot, while the apron was composed of rough stone

blocks 9 by 3½ by 2 feet, laid in uneven courses. All the interst were filled with large rubble. Repairs were first made in 184 thereafter were carried out on a slightly different plan, (*B*) the eral section being retained. The repaired dam appeared as here cated. These illustrations give a fair idea of the attention give the natives to this class of work and indicate the fallacy of tru to size and position of the material instead of to the homogen the work. Notwithstanding the employment of large blocks of and skillful application of material the dam was breached five between 1842 and 1863.

A later development is indicated in the cut given of the Mu weir (fig. 10, *C*). General Greene retained the native section of weir, but corrected its chief failing by building an impervious and mortar face against its upper side. The natives, with the of decreasing the depth of water flowing over the weir in flood carried the work in a curved line, its general direction upstream. The length of the weir was nearly double the breadth of the river, and its crest was at different levels in diff places; the part next the head sluice being invariably lower tha rest relieved the head of water pressure against it during flood these features, shown by experience to be desirable with the works, are so many defects with the solid masonry work now ad The regulators in the old works at the heads of canals were constructed of rough stone posts, the openings between which stopped with rough timber and fulfilled their objects in an imp manner.[a]

In regard to the two main designs adopted by modern practi weirs, namely, the open and the closed or solid weir, the advanta the latter is that it is self-acting and if well made requires no rep or maintenance. Its first cost, however, is greater than tha open weir, and it interferes with the regimen of the river, ca deposits of silt above it and perhaps making the river seek a channel. The open or scouring sluice weir interferes but litt the normal action of the river. The scour produced by openi gates prevents the deposit of silt and its first cost is less than tha the closed weir. Another form of weir, the best examples of are to be found in the barrages of France, consists of a weir op whole width of the channel, the object being to prevent in flood the water being backed up, thus submerging valuable pr above the weir. The obstruction in the river channel may be e removed by opening the gates the full width of the weir.

The ordinary weir consists of a masonry floor acting as an a properly founded and carried across the entire width of the rive with the level of the bed and protected from erosive action by walls up and down stream. On a portion of this is construct upper work, which may consist of a solid wall and part ma

[a] Sankey, Maj. R. H., Roorkee Professional Papers, No. 141, Roorkee, India.

s, the interstices between the latter being closed by some tem-
ıry arrangement, thus creating the scouring sluices. Weirs proper
in no instance to be looked upon in the light of storage works.
y may for a trifling period during the dry season answer that
ɔose, but the irrigation from them depends in all cases on the
inual flow of a small quantity of water or upon an auxiliary sup-
from storage waters situated higher up. In speaking of the mode
ɔnstructing low diversion weirs with long slopes, Col. Baird Smith
:

rivers with beds of pure sand and having slopes of 3½ feet per mile such weirs
be constructed and maintained at a very moderate expense, and the elevation
e beds of the rivers on the upper sides of these weirs to the full height of the
ns is an inevitable consequence of their construction and no arrangement of
r sluices has yet been effective to prevent this result.

ı regard to founding these structures on wells, he further says:

pure sands acted on by currents due to a fall in the river bed of 3½ feet per
, and exposed to the action of floods from 12 to 15 feet deep, well foundations
ont and rear of 6 feet in depth have been proved by experience to be safe.[a]

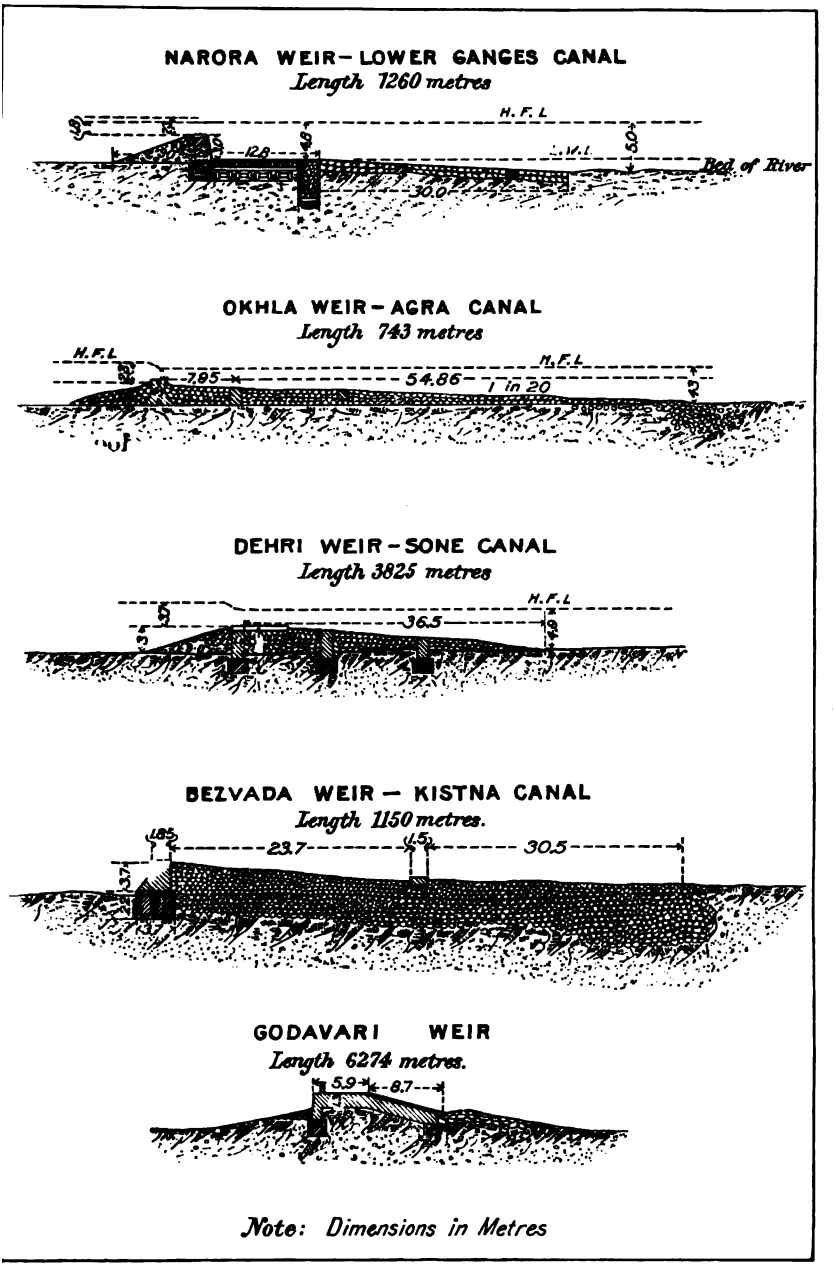
s a general rule the masonry apron should have a thickness equal
ne-half and a breadth between three and four times the vertical
ht of the weir forming the obstructive part of the dam. The effi-
cy of the dam depends upon the construction and careful main-
ınce of the apron. In time of freshets the water backed against
toe of the weir has a protecting effect on the apron by producing
ater cushion, and as the flood rises the height of fall from the weir
t gradually diminishes, and in a flood of 16 feet over an ordinary
r it wholly disappears, leaving scarcely a ripple on the surface to
cate the existence of the masonry mass below.
ı the construction of weirs in rivers with sandy beds, wells may be
sidered as the feature of Indian engineering. These are essen-
ly open blocks or cylinders of brick usually sunk in the bed of the
r at low stage and are protected by temporary sheet piling placed
ween their outer edges, while the intermediate spaces are being
d in with concrete, thus forming a solid wall floating in sand, upon
ch is built the superstructure of the weir, scouring sluices, apron,
retaining walls. Whatever the form of foundation, be it gravel
hardpan, solid rock or wells, the first portion of the weir con-
ıcted is the scouring sluices, which are carried on at the same time
h the regulators at the head of the canal. This order is pursued
ause after the construction of the scouring sluices the water in the
er may be diverted through them while the work upon the remain-
of the weir is progressing, and especially so that it may be passed
ough them when the closing of the weir is effected. The heaviest
ɔd of water takes place through these scouring sluices, and in their
ıstruction the very best workmanship and material are required.

[a] Smith, Col. Baird, R. E., Italian Irrigation, London, 1856.

The weir may, if desirable, progress at the same time with these preliminary works. The cross section of the weir is neither as long as flat as that of the foundation and sluiceways. When the c[illegible] of the weir is effected the low water in the channel is diverted th[illegible] the sluiceways, sand or other material available is carried acr[illegible] last opening, foundations are built up as rapidly as possible, an[illegible] superstructure closed.

Where a good rock foundation is obtainable in the bed of the [illegible] close to the surface the weir is given an entirely different cross se[illegible] from that of weirs constructed of other material, and is built thro[illegible] out of the most substantial masonry laid in cement. In the ca[illegible] some weirs, the overfall height of which is not great, the cross se[illegible] is made nearly vertical upstream, and a slight slope, perhaps 4 on [illegible] given on the downstream face, which is usually so curved as to [illegible] away the flood water with the least shock to the dam. In the ca[illegible] higher weirs of this character, or those over which great f[illegible]ds m[illegible] discharged, it is usual to make the downstream face nearly ve[illegible] giving a sufficient top width and slope to the upper face to insu[illegible] stability of the structure and bring the resultant line of pre[illegible] within the middle third. The object of the vertical slope on the d[illegible] stream face is to give a clear overfall for the flood water. This [illegible] on the water cushion formed by the construction of a subsidiary [illegible] placed some little distance below the main weir, and backs the [illegible] up against its base. In all forms of overfall weirs liable to the [illegible] shock of large floods it is customary to construct these subsi[illegible] weirs, some examples of which will be given in their proper pl[illegible] In the location of such weirs, a broad reach of the stream is el[illegible] for the site of the main weir in order to reduce the height of [illegible] passing over its crest; while the subsidiary weir is, if possible, lo[illegible] in a narrower place so as to produce the greatest depth of wa[illegible] the toe of the upper weir. Scouring sluices of limited cross-sec[illegible] area are introduced in such weirs as these, their object being to [illegible] a clear channel immediately in front of the canal regulators.

Of weirs founded on wells in sandy rivers, that at the head of [illegible] Lower Ganges canal at Narora presents a peculiar type, being [illegible] stantially built of masonry and with a profile similar to that of [illegible] masonry weirs just described. This weir is constructed entir[illegible] brick, chiefly because of the cheapness of the material at Naro[illegible] consists of a wall 8 feet wide at bottom and 7 feet at top, the cre[illegible] which is 9½ feet above the river bed. The upstream slope is ve[illegible] while the downstream slope is nearly so. It is protected on the [illegible] side by a quantity of loose rocks or bowlders thrown into the [illegible] bed nearly flush with the crest. On the downstream side is an [illegible] nearly 150 feet wide to receive the impact of the falling water. [illegible] first 40 feet of this apron is composed of masonry resting on fou[illegible] of shallow wells, abutting at its lower end against a row of [illegible]



CROSS SECTIONS OF MODERN WEIRS.

low this is a considerable depth of loose hand-packed bowlders rried out to the extreme toe of the apron.

The total length of the masonry portion of this weir is 4,125 feet, luding the scouring sluices at the head of the regulator, which are 7 feet long. The left end of the weir rests on an earth embank-nt a little outside of or beyond the river channel. This embank-nt is 1,000 feet long with an angle at the shoal end, and is carried up e stream for some distance, thus protecting the low river bottom on at side from flooding. Detailed drawings of this weir showing its ss section, the plan of its foundations, and the arrangements of e embankment and canal head are presented. (Pls. XI and XII d fig. 22.)

Another and very common type of weir founded on wells is that rep-sented by the weirs at the heads of the Agra and Soane canals l. X.) The weir at the head of the Agra canal, as first constructed, d too bold a cross section, and during several successive years the wer end or toe was carried away in time of flood. It has remained tact ever since its reconstruction in 1875. This weir is without undations of any sort, resting on the river bed. It consists of a all of masonry 4 feet wide on top and a little wider at base forming e main crest line of the weir, the height of which is 10 feet above e river bed. From this crest the slope upstream is carried to a dis-nce of 40 feet, and consists of large stones hand packed and laid y. The downstream slope is very flat, averaging about 1 on 20, and carried a distance of 26 feet to a point at which is constructed nother masonry well similar to the first and resting on the river bed, s line being parallel to the axis of the weir for its entire length. me distance below this is a smaller well similar to the two previ-sly mentioned. The entire remaining portions of the weir consist large stone blocks dry packed, the walls acting as bars to prevent eir sliding.

This weir is 2,573 feet long from the right bank at the canal head, e left wing resting on an island in the middle of the Jumna River. n embankment 20 feet wide on top was carried thence to and across e east channel and thence up the left bank of the river for some iles. The scouring sluices are 139 feet wide, and are substantially unded on four lines of wells. In order to prevent the destruction of is weir by the action of flood waters, groins of a peculiar shape, called lligator groins, are constructed on both the upstream and downstream des at intervals across the channel of the river and parallel to the urse of the stream. The object of these is to deflect as much water s possible toward the right bank with a twofold object—first, the estruction of an island which obstructs the channel just above the anal head; and second, to aid the under sluices in sucking or draw-ng water toward them at low water, thus affording a sufficient dis-harge in front of the canal head.

The Soane weir (fig. 12) is similar to the Agra weir in general construction, but resembles that at the head of the Midnapore canal more than any other. It consists of three parallel lines of masonry running its entire length and varying from 2½ to 5 feet in width. The main wall, which is in the central axis of the weir, is 5 feet wide and 8 feet high, and all three lines of walls are founded on wells sunk from 6 to 8 feet in the sandy bed of the river. Between these walls is a simple dry stone packing. The upstream slope is 1 on 3, the downstream slope 1 on 12, and the total length of the lower slope is

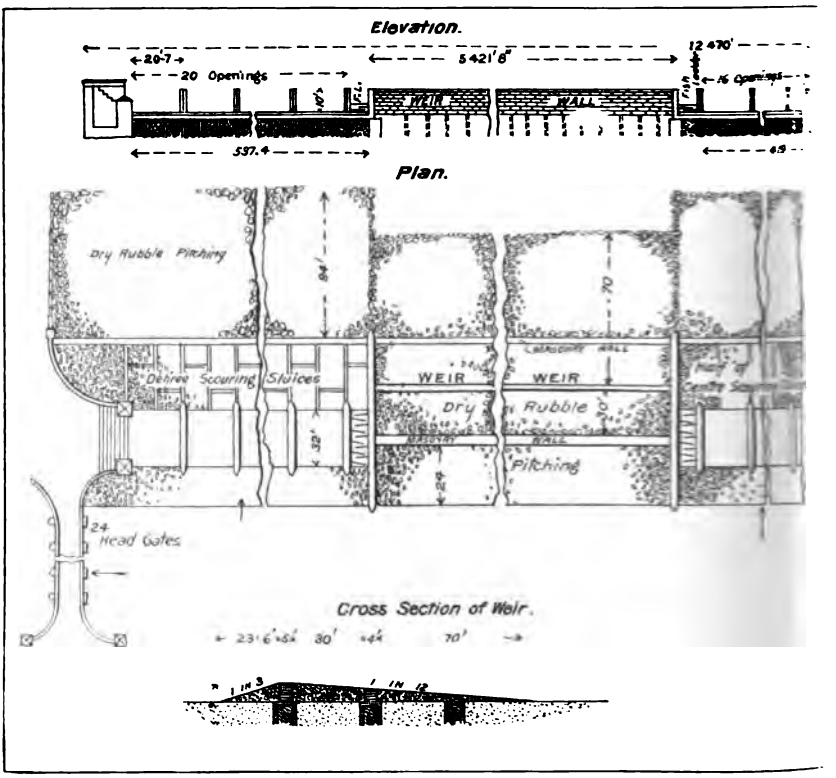
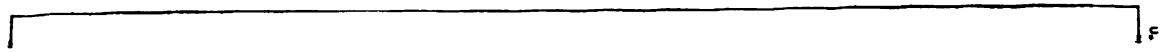


FIG. 11.—Plan of Soane weir.

94 feet. The total length of the weir is 12,470 feet, and it is 19.5 feet in height, including its foundations. On top, hinged to the back edge of the crest wall, is a row of iron shutters (fig. 13), each 1[illegible] long and 22 inches high, which are supported by struts, so that when the river is low they increase the diverting height of the dam by [illegible] inches, and in time of flood they fall automatically, thus giving the flood a solid masonry crest over which to flow. These shutters are held in place by an iron rod hinged to their centers on the upstream side at about one-third of the height from the base.



The weir across the River Ravi (fig. 14) at the head of the Sidhnai canal represents a new and different type of construction. At the

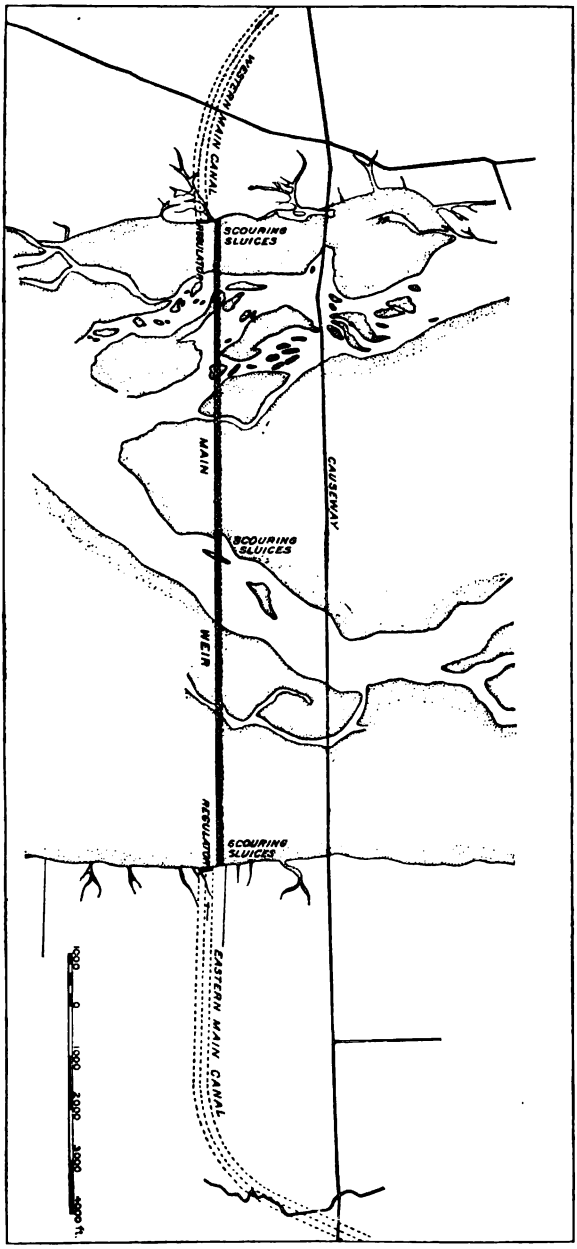


FIG. 12.—Plan of head-works, Soane canal.

point where the weir is built (fig. 15) the river bed for 250 feet on the left bank and 200 feet on the right bank gives a good clay founda-

tion for a reasonable depth below the top of the weir, but the central portion, 390 feet long, is of sand too deep to permit of carrying the foundation to the underlying clay. A trench was dug through this

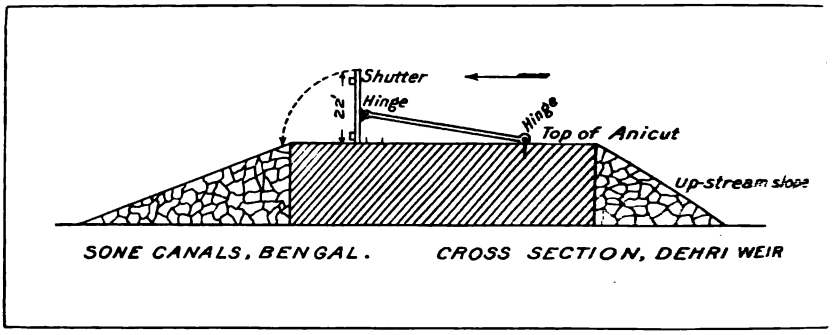


FIG. 13.—Shutter on Soane weir.

central sandy portion to a depth of 13½ feet below the crest of the weir and for a distance of 400 feet, and sheet piles 10 feet long were driven into the sand as a protection for the foundation, and to prevent excessive percolation below the level of the weir. The highest recorded flood would pass 10 feet over the weir crest. The crest of the weir supports a row of wooden needles which are readily removable and are 7.5 feet long. They are placed between masonry pillars about 5 feet apart, thus increasing the effective diversion height of the weir by their length. This mode of construction is indicated in fig. 19, and the action of the needles is more fully described elsewhere.

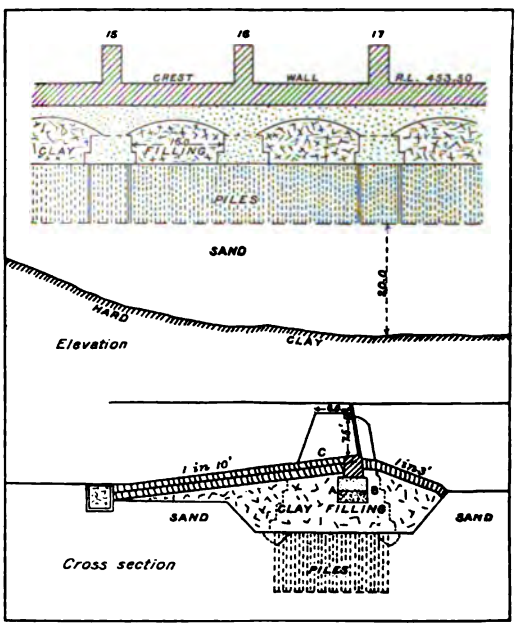
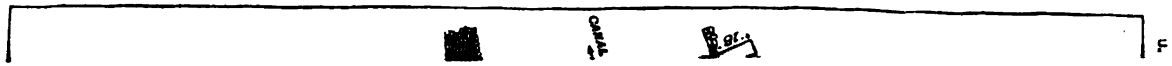
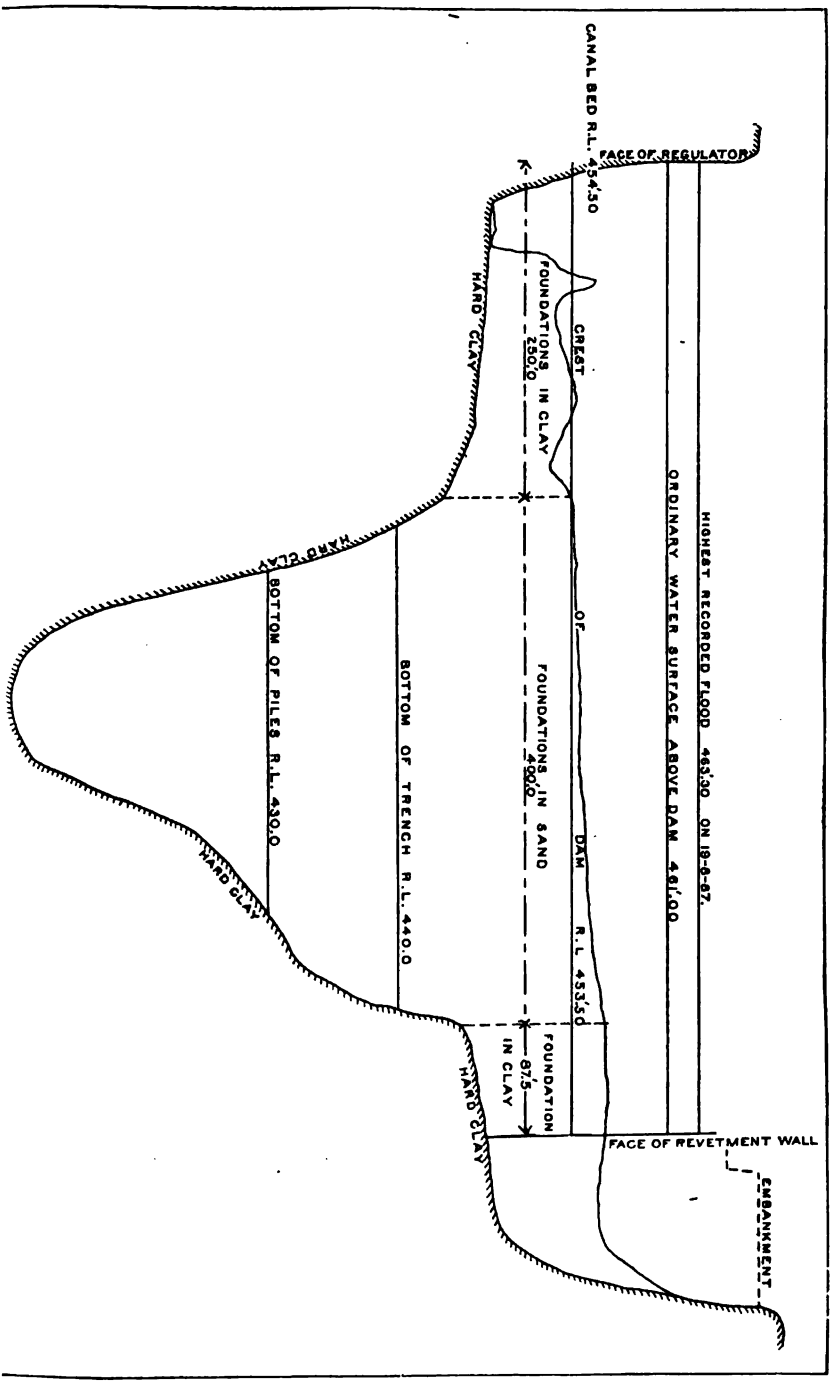


FIG. 14.—Sidhnai weir.

Of temporary weirs the most notable example is that at the head of the Ganges canal above Hardwar (fig. 18). At this point the bed of the river is composed of bowlders of various sizes to a considerable depth. The head-works of the canal consist of a number of separate structures extending up the river above the head of the canal proper




HIGHEST RECORDED FLOOD 463.30 ON 19-8-87.
ORDINARY WATER SURFACE ABOVE DAM 461.00
FACE OF REGULATOR
CANAL BED R.L. 454.50
CREST OF DAM R.L 453.50
FOUNDATIONS IN CLAY 250.0
FOUNDATIONS IN SAND 250.0
FOUNDATION 87.5 IN CLAY
HARD CLAY
HARD CLAY
HARD CLAY
BOTTOM OF PILES R.L. 430.0
BOTTOM OF TRENCH R.L. 440.0
FACE OF REVETMENT WALL
EMBANKMENT

a distance of several miles. The bed of the river is divided into several channels, the principal one being the Hardwar channel, from which the canal is diverted and into which the greater part of the water in the stream is trained by means of various works. The general plan of these works is given in the accompanying sketch. At the upper end of the bifurcation of these channels is a masonry wall or bar constructed across the left-hand channel, the object being to force the water toward the Hardwar or right bank. The Hardwar channel from this point on is protected and trained by means of a series of permanent bowlder embankments, terminating on their ends in masonry noses. On a minor channel a little lower down a permanent weir is constructed, close to the right bank, to prevent the Ganges from cutting too far in that direction; and a trifle below this, crossing a channel leading to the left bank, are the diverting weirs proper, consisting of a series of three temporary bowlder dams, built across the channel one behind the other in such a manner that the leakage through the first will be caught by the second and turned back into

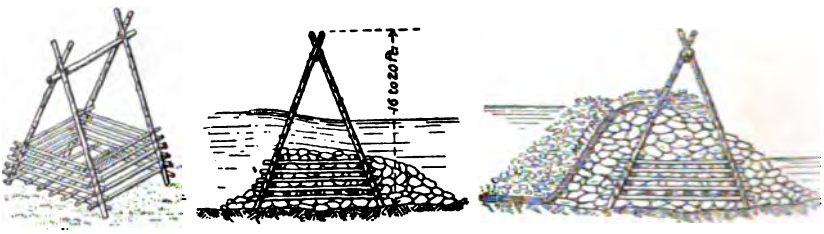


FIG. 16.—Details of temporary dams, Ganges canal heads.

the Hardwar channel, and that from the second will be caught by the third and diverted again to the Hardwar channel. These dams are destroyed each year by the floods and it has been found necessary entirely to rebuild them annually, new bowlders being brought down for the purpose, as the old ones are carried too far away to be economically collected. Experience has shown that this mode of construction of temporary weirs is less expensive than would be that of a permanent one at this place.

Large pyramidal-shaped cribs of timber are formed in the roughest manner and when placed in position are filled with bowlders (fig. 16). Bowlders are then thrown on top of these to strengthen and raise them higher and the channel face is covered with small branches and small bowlders and sometimes with earth to prevent excessive leakage. The velocity is about 10 feet per second in the major portion of the Hardwar channel, and its abrading effect is excessive, in consequence of which lines of temporary and of permanent bowlder banks and small masonry dams are carried from this point the entire distance along the sides of the channel to the main regulating weir below Hardwar. Just beneath and below the bowlder weirs above referred to masonry

ırs are sunk in the bed of the side channel to prevent retrogression levels, and a few hundred yards below and about opposite the city Hardwar is a third channel leading from the Hardwar into the left ıannel. This is stopped by a permanent half-open masonry dam id on a solid bed of masonry. In times of floods the sluice gates ay be removed, while at low water their insertion closes the channel. The regulating gates are at Myapur, at the head of the canal. Here e also the weir and scouring sluices proper. The latter works con-st of a weir of solid masonry founded on the bowlder bed, with 15 ouring sluices, each 10 feet wide. The weir proper is only 525 feet length, of which 200 feet are occupied by the scouring sluices and ıeir piers. The sluiceways are deep and are closed by double sets of ıtes, some of which are raised and lowered by means of a traveling inch, the remainder being closed by simple planks or flashboards ıid in the grooves.

SCOURING SLUICES.

The scouring sluices placed in open weirs consist of the foundation, ıe floorway, and the superstructure. The floor must be deep and ell constructed and carried for a little distance above the weir and or a considerable distance below it. Above this are built up masonry iers at regular intervals, placed from 6 to 12 feet apart, and grooved or the reception of planks or needles, or closed with automatic gates r some other device which can be rapidly removed or replaced. By his means the water is kept under control and when low can be aised to the level of the crest of the weir by closing the gates, while n time of flood they are opened to secure a scouring of the river hannel in front of the canal regulators. The masonry flooring is arried the entire width of the sluiceway, flush with the river bed and ıbuts well into the bank of the river. This is protected by a curtain vall of masonry up and down the stream.

The sluices in the weir at the head of the Lower Ganges canal at Narora are 38 in number, each 7 feet 10 inches in the clear. They ıave a total length of 427 feet, and the masonry piers separating them ıre but 2½ feet wide. The total length of these piers parallel to the course of the stream and at right angles to the line of the weir is 36 feet 4 inches, and they are practically two stories high, the upper deck or gallery having been constructed to have sufficient headroom to raise the gates (fig. 22). These gates are lifted by traveling winches running on rails on the upper deck. The sluiceways, like the main weir, are founded on a series of wells sunk in the sands and connected by brick masonry arches between which is a solid filling of brick (Pls. XI and XII). The total breadth of loose stones on the upstream approach to the sluiceways is 30 feet, and the total breadth of the bed of the sluiceways is 150 feet. Beyond this masonry flooring is carried and flooring of broken stone well packed for a distance of 100 feet

farther. The depth of the floor is 3 feet. The arrangement of sluiceway relative to the remainder of the weir and head-works is shown in Pl. XIII. The sluice gates are substantially constructed of wood and iron, and are two in number in each opening, the upper row when lowered abutting against the top of the lower row. In time of great floods both sets of gates may be entirely raised clear of the flood line.

The gates in the weir at Myapur, at the head of the Ganges canal, are similar to those described, and are represented in the accompanying illustration (fig. 17). The sluices in the weir at Okhla, at the head of the Agra canal, are similar in design to all others of this class, and contain 16 openings having a sluiceway of 138 feet. The openings, feet wide by 10 high, are built into a masonry structure 19 feet high, and the gates slide between piers 2½ feet thick; they are raised by

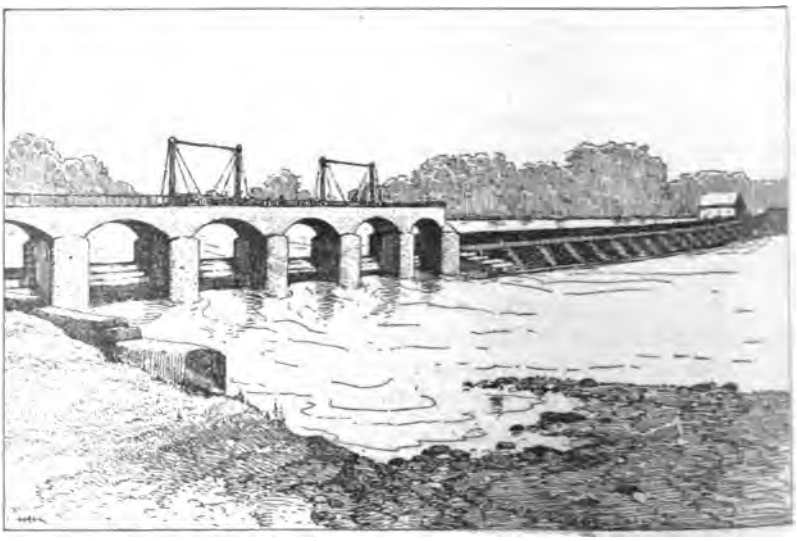


FIG. 17.—Myapur dam, Ganges canal.

traveling winch from above. The floor is founded on four line wells, and is 11 feet below the crest of the weir. The pavement this floor is 8 feet wide upstream, 41 feet downstream, and 12 feet the center of the weir. This is practically a single structure resting on the sand of the river bed, and is subject to considerable leakage. It is required not only to carry the weirs and their superstructure, also to withstand the force of a torrent of water 16 feet deep.

Among the earliest and for that reason most interesting series automatic sluiceways constructed are those in the Mahanadi in lower Bengal, at the head of the Orissa canals. The sluice consists of 10 bays each 50 feet wide and separated by masonry piers. Each bay is closed by a double row of timber shutters fastened wrought-iron bolts and hinges to a heavy beam of timber embedded

HEAD-WORKS, LOWER GANGES CANAL, NARORA.

the masonry floor of the sluice.[a] There are seven upstream and en downstream or rear shutters, the latter 9 feet high above the or, and the former 7½ feet high.[b] During floods the upper row of utters, which fall forward, are fastened down by clutches in an most horizontal position, while the rear set, which fall backward or wnstream, are kept in a horizontal position by the rush of water er them. In the dry season the rear shutters do duty by damming water up, and for this purpose are provided with strong wrought-n struts attached to their lower sides. In order to lift these the stream set are first raised. This operation being aided by the press water beneath, they are permitted to rise to a vertical position by ans of a chain guyed to the floor above them. Relieved of the ter pressure by this upper set of shutters it then becomes possible raise the lower set, after which the upper set are lowered again o their original position, and the weir is in position to withstand a

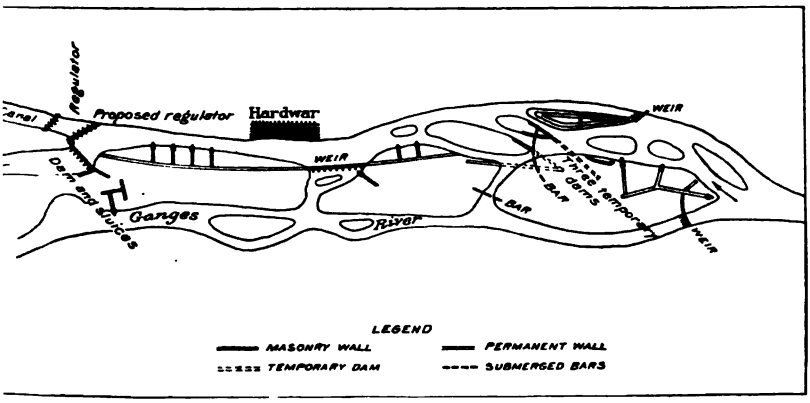


FIG. 18.—Head-works and weir training works, Ganges canal.

ood, as the lower set can be instantly dropped by merely removing e bolts which support them. The redamming of the water is accomished in less than a minute. By reversing a lever each upper shutter released, when they rise more or less rapidly, but with a comparavely slow motion until near the water surface, when they are brought me with a jerk, which does not seem, however, to cause a great rain.

Probably the best example of automatic or self-acting sluice gates e those constructed in the weir at Dehree, at the head of the Soane nals.[c] The sluiceways in this weir consist of three separate sets, e of which is placed close to the head of the main western canals, d are 537 feet 4 inches in length, containing 20 openings separated

[a] Roorkee Professional Papers, vol. 7, 1870, p. 75.
[b] Medley, Lieut. Col. J. G., Manual Thomason, College Civil Engineering, Irrigation Works, orkee, India, 1873, vol. 9, p. 118.
[c] Buckley, R. B., Fixed and movable weirs: Proc. Inst. C. E. London, 1879-80, vol. 60, p. 64. edley, Lieut. Col. J. G., Manual Thomason, College Civil Engineering, Irrigation Works, oorkee, India, 1873, vol. 9, p. 118.

by masonry piers. In the middle of the weir is another set of openings 419 feet in length, and at the extreme eastern end of the weir, below the head of the main eastern canal, is another set sluiceways 537 feet 4 inches, with 20 openings. In addition to the sluiceways there are, as in all Indian weirs, one or more fish ladders. In the Soane weir there are four separate fish ladders, one at the end of each of the shore sluiceways and one on each side of the central sluice.

The crest of the weir is 9½ feet above the river bed. The gates which the sluiceways are closed are each 20 feet long and 9½ feet high. They are separated by masonry piers each 6½ feet wide and 32 feet long. As at first constructed these piers were much smaller, but it was found they would not withstand the jar produced by the manipulation of the gates and their thickness has since been increased. It

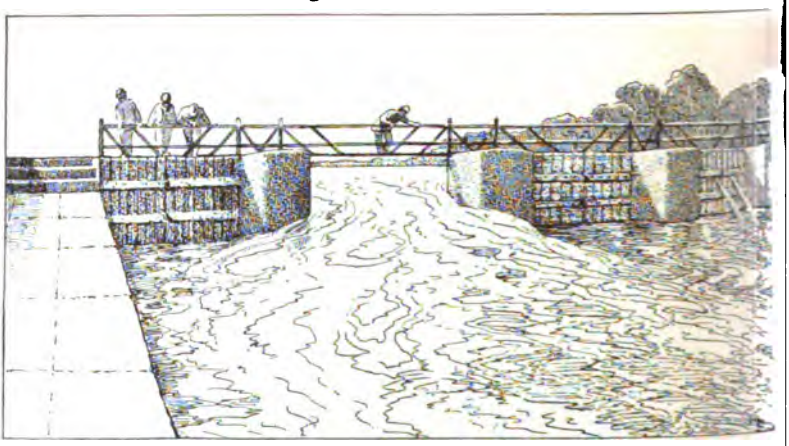


FIG. 19.—Dropping the Soane automatic sluices.

estimated that the velocity of the current through these scouring sluices is about 17½ feet per second. The floor of the sluices is [illegible] wide, parallel to the river channel. As at first designed this floor consisted of a substratum 4 feet thick of rubble paved with good stone 6 inches thick, but the difficulty of this construction was such that it was abandoned, and the foundations were finally set on blocks. The blocks are 10 by 6 feet, with two well openings each, and were built feet high upon bamboo curbing laid on the surface of the sand, and when the brickwork had set they were sunk until their tops were foot below water. Concrete was then thrown into the wellholes and around them, and when set in left a solid foundation for the masonry. The ashlar pavement on this solid floor is 15 inches thick in the bottom of the scouring sluices and 9 inches thick over the apron. Twenty feet upstream from the sluice flooring is a line of wells sunk 10 feet, a curtain wall to the apron, and the wellholes and interspaces are filled with concrete, as in the foundation of the flooring. The space between

curtain wall and the sluice flooring is packed with large bowlders covered with pavement 9 inches thick. Twenty-five feet downam from the flooring of the sluices a line of wells has been sunk 10 and formed into a solid wall; the spaces between this wall and the ing have been tiled and packed with bowlders and stone, and downam from this point a talus, composed of large bowlders and blocks one, stretches 50 feet farther. The whole length of the sluice floorparallel to the river channel is 200 feet. Notwithstanding the l workmanship of this foundation, the floods of 1874 proved very ructive, and tore away much of the river bed to a depth of 38 feet w the toe of the talus.

he mode of construction and operation of the sluice-gates themes is as follows: These gates (fig. 25) are constructed of wood, well

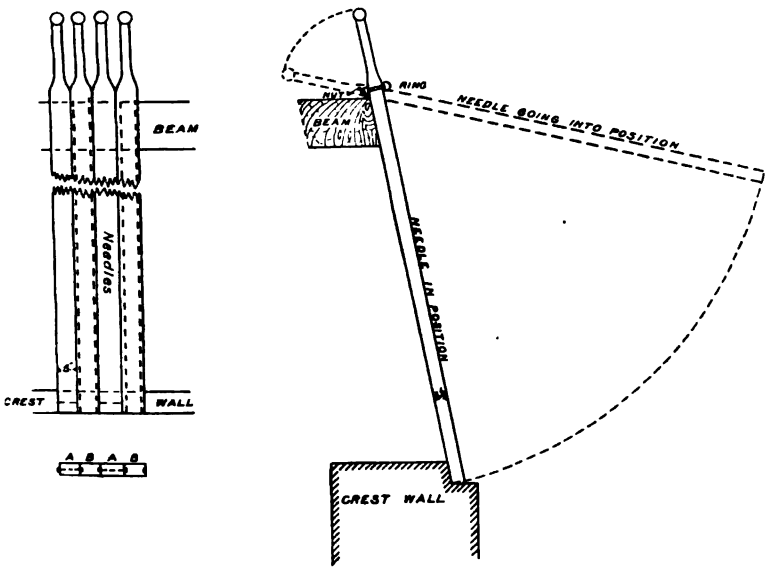


FIG. 20.—Details of Sidhnai weir.

ced, and there are two for each opening. For each alternate pair piers on the downstream flooring a low masonry wall 1 foot high is lt out, which holds 1 foot in depth of water, thus forming a water hion on which the lower gate falls and relieving the piers of a porn of the shock. The upper gate falls upstream, being hinged to the r at its bottom, and abuts against a series of six struts, hollow iron inders with small vent holes in which pistons work, so that when gate is raised by the water under it the impact against the struts elieved by the pistons plunging in the water in the cylinders. The vnstream gates fall downstream (fig. 19), and are supported by four n rods hinged to their upper face below the center of gravity, and en in position are held upright by chains attached to the piers. If th gates are open and it is desired to close the lower one, so as to

cause it to dam the water up, the operation is performed in this ma
The lower gate is first relieved by pushing aside the catch w
attaches it to the floor, and is raised a little by means of a hand l
whereupon the force of the water on the under surface brings
slowly for a short distance, when it comes up with a jar again
cylinder struts.

The pressure is now relieved from the lower gate, which
raised by hand levers and chained in an upright position to the p
The upper gate is again lowered, now falling chiefly by its own w
through the water, and is fastened down. The lower gate, now
ing as a dam, is prepared to be released at a moment's notice.

The needles used on the Sidhnai weir (fig. 20) are an improve
on a very ordinary form of gate found in most of the simpler
older structures. At the heads of many old canals, and in some
ways, gates are found closed by two classes of needles, the s
consisting of planks or flashboards let horizontally into grooves
piers and raised or lowered, one at a time, until a sufficient nu
have been removed or introduced to regulate the discharge of w
The needle is formed by inserting these planks vertically b
timber guides or abutments laid horizontally between the pie
water being regulated by the removal of as many as may be de
The needles employed on the Sidhnai weir are made of hard wo
such weight as to be manipulated by a strong man, each needle w
ing not over 40 pounds. They are 7½ feet by 5 inches by 3½ inches
size, with a stout handle 1½ feet long ending in a knob.[a]

The most difficult problem when these needles are in position
make the dam water-tight. Several methods were at first prop
Grooved needles were found to be unnecessary; ordinary needle
the interstices between them were filled with wood shavings
chopped straw, were found to be readily made water-tight. Afte
needles are placed in position they are forced together by being dr
horizontally with a crowbar, and a basket filled with shavings
is slipped down in front of the leak to be closed, the calking mat
being drawn by the current into the openings.

CANAL REGULATORS.

A set of regulating gates is always constructed at the head
canal. They must afford sufficient way to admit all the water the
is estimated to carry, and by them the amount admitted can b
trolled. Like the scouring sluices, these regulators consist of a
grooved piers resting on a foundation carried across the canal b

The water may be controlled by a set of planks or needles w
by hand in grooves, or, as is more usual, by drop gates raised an
ered by a winch from above. When not under too great a head
opening is closed by a single gate raised by a hand windlass or w

[a] Sidhnai canal project: Selections of Records of the Government of India, No. 268, Ca

ome cases, under considerable pressure, a double series of gates, above the other, is used, or else valve gates are employed, which worked by hand levers and screws from above. It is customary onnect the piers of the regulator by arches, so as to form a bridge ss the canal, at the same time affording a convenient platform which to operate the gates. The bed and banks of the canal at head are protected by masonry, so as to be safe from erosion when gates are opened.

locating the position of the regulating sluices, the principal ct is to bring the water in the river through the scouring sluices ich a way that it shall pass directly in front of the regulator, pre- ing the deposit of silt at its head. This must be so established the canal will receive the desired volume of water with the least ility of receiving the heavy silt through the regulators or to dam- from matter carried by floods. Where this relation between ring sluices and regulators is such that the least eddy or quiet er exists between the two, there is certain to be a deposit of silt, ch is an element of danger and must be removed. At the head of

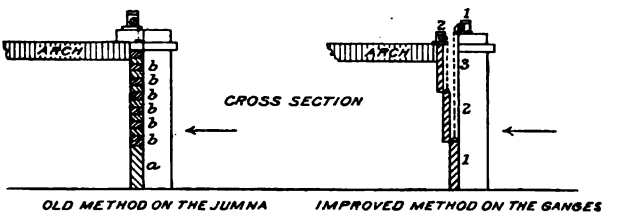


FIG. 21.—Regulating gates, Ganges and Jumna canals.

Ganges canal the location of the regulating gates is such that ry deposits of silt are formed. At the head of the Soane canal face of the regulator is set back 30 feet from the abutment of the ring sluices, and here also is a heavy deposit of silt. At the Bari b head-works the regulating sluices are close to the scouring ces and the current is so strong that small bowlders and gravel are ied through into the canal. The head-works of the Agra canal excellently located, and the river channel and canal line are so rly at right angles to each other that apparently no silting takes e. At the head-works of the Lower Ganges canal little or no silt- occurs, owing to the excellent relative location of the various ceways.

t Myapur, the head of the Ganges canal, the regulating bridge has ays or openings, each 20 feet wide and 16 feet high, fitted with es and apparatus for opening and closing. The breadth of the base platform on which the piers rest is 48 feet, exclusive of the cut- ters, which project upstream 4 feet. The roadway on top of the dge is 37 feet 9 inches wide between the rear parapet and the row windlasses on the upstream front. The shutter for closing the regu-

lators, while an improvement on that used on the Jumna canal, however, rather crude compared with the modern and improved methods employed on later constructions. The accompanying sketches (fig. 21) indicate the method of arranging the regulators on the Jumna and on the Ganges canals. On the Jumna canal a regulator or drop gate are placed in a simple groove, and sleepers of scantling inches square are dropped in the top of the gate. This has always acted efficiently, but time and labor are required in its manipulation. On the Jumna canals there is no great volume of water to contend

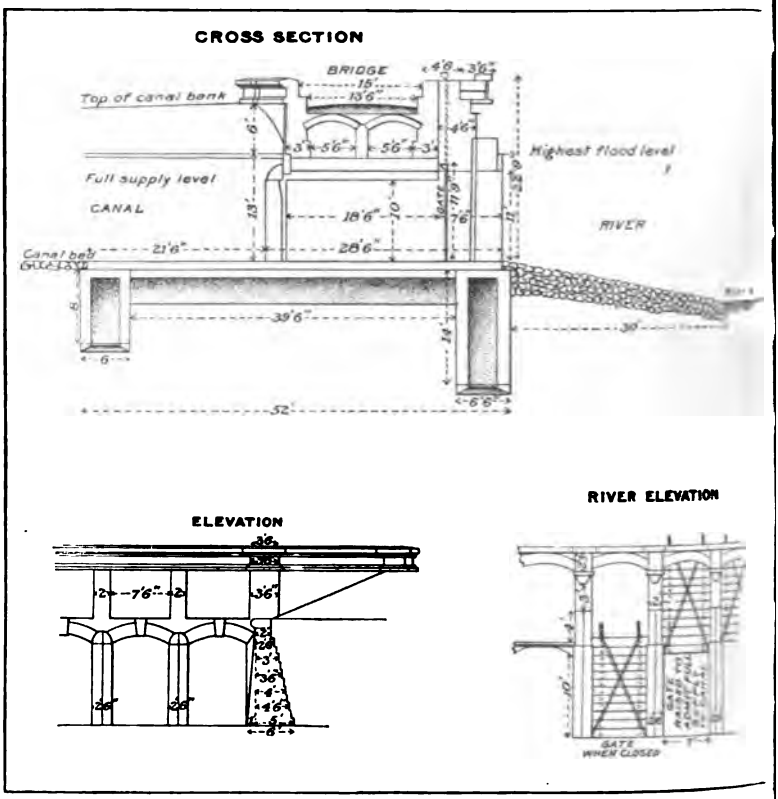


FIG. 22.—Narora weir, Lower Ganges canal; detail of canal sluices.

with, nor is there as large a number of bays as on the Ganges canal. On the latter, as shown by the illustration, the bay is divided into three series of gates, the most advanced one having its sill at the level of the canal bed, and two higher series of gates, each having their sills revetted 6 feet and retrograding toward the face of the bridge. These are operated by separate windlasses over each. The two lower series are quite independent of each other, the third or upper bay is closed by simple sleepers. The machinery attached to these gates is of the simplest character and readily understood by the common laborer, while it is not liable to disarrangement.

From the plan of the relative locations of sluice-head (fig. 23) l regulating bridge it will be seen that the triangle in front of the er affords an immense backwater or eddy in which deposits of silt st necessarily take place. Designs have recently been submitted a new regulating bridge which shall be a skew arch, the front face entrance to the regulators being parallel to the channel of the nges and at right angles to the scouring sluices, the rear side being right angles to the channel of the canal.

An interesting and unique set of regulating gates, because of the at pressure under which they are worked, are those at the head of Betwa canal (fig. 49, p. 177), and attention is called to them in this

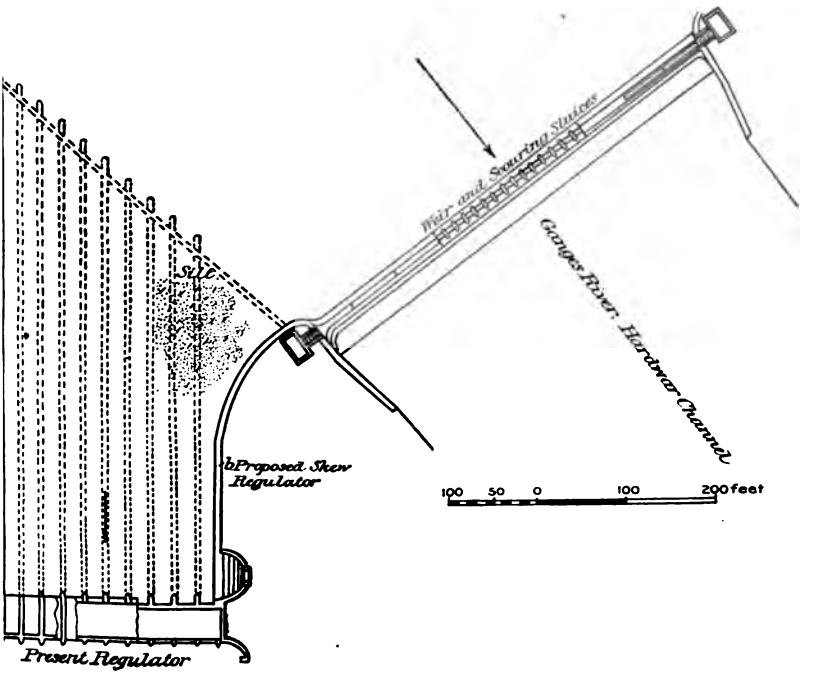


FIG. 23.—Head-works, Ganges canal.

ice, though they will be more fully described later on. The regu- ors at the head of the Soane canal are placed at right angles to the uring sluices, though they are set back a short distance from the line the curtain wall leading to the scouring sluices. The floor of these gulators is about 3 feet above that of the scouring sluices. The sonry work in connection with the head-works of this canal is well nstructed, but perhaps too elaborate. These regulating sluices are signed to discharge 4,500 second-feet with a head of only 4 inches d a depth of 9 feet of water. They consist of 24 openings, each 6 et wide, and separated by the solid piers which support the bridge ove. There are two shutters constructed of wood, opening verti-

cally (fig. 24). Usually only the upper gate is used, the chief dep of silt thus taking place in front of the lower gate, where it is easi dredged out, but when the head of water is very low the lower gate sometimes raised. The silt is thus flushed out and deposited in canal, where it is still more easily dredged. These shutters are ra by a traveling winch supported on a hand car on rails on the bri above. The figure shows the mode of raising these gates an fastening them together when both are to be opened.

At Vir, where the head-works of the Nira canal are situated, regulating gates are simple, giving a water way through seven separate bays, each 4 feet wide, and operated from a masonry bri above (fig. 45, p. 170). These are so designed that under the low available head of 9 inches the full discharge required will be admitt to the canal.

The regulators at the head of the Lower Ganges canal, like the w and scouring sluices (Pl. XIII and fig. 22), are founded on two

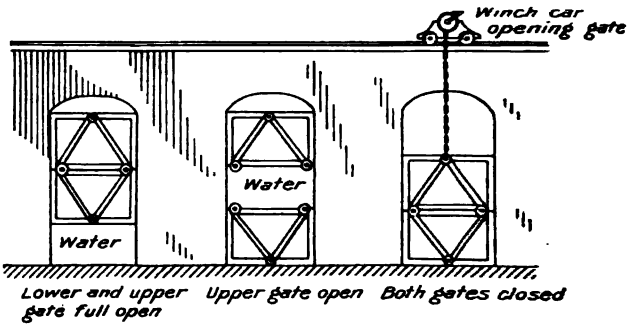


FIG. 24.—Regulating gates, Soane canal head.

of wells. Curtain walls founded on wells are carried along the ba of the river and canal for a short distance. The flooring of the reg lators is well paved with substantial masonry from 3 to 5 feet thi and a rough loose-stone pavement is carried for some distance i the river above the regulators and 100 feet below them, the bank the canal being revetted for some distance farther. The width at canal head is a little greater than that of the canal, causing velocity for a short distance to be diminished, in consequence of wh the majority of the silt is deposited at this one place, where it ca most conveniently removed. The total width of the regulators a head is 282½ feet. There are 30 bays, each 7 feet wide, separate substantial masonry piers 28½ feet long by 2½ feet wide. The closing the entrance to the canal head are of iron and slide vertic They are each 11 feet high, are raised by a winch traveling o bridge overhead, and are closed by their own weight. In the pier the upstream side of these gates are grooves in which planks ma inserted in order to reduce the head on the gates when opera them.

'he regulator at the head of the Sidhnai canal consists of four 60° hes of 22.5 feet span, with jack piers 2.5 feet thick in the center, ich divide the waterway into eight spans of 10 feet each. The arches

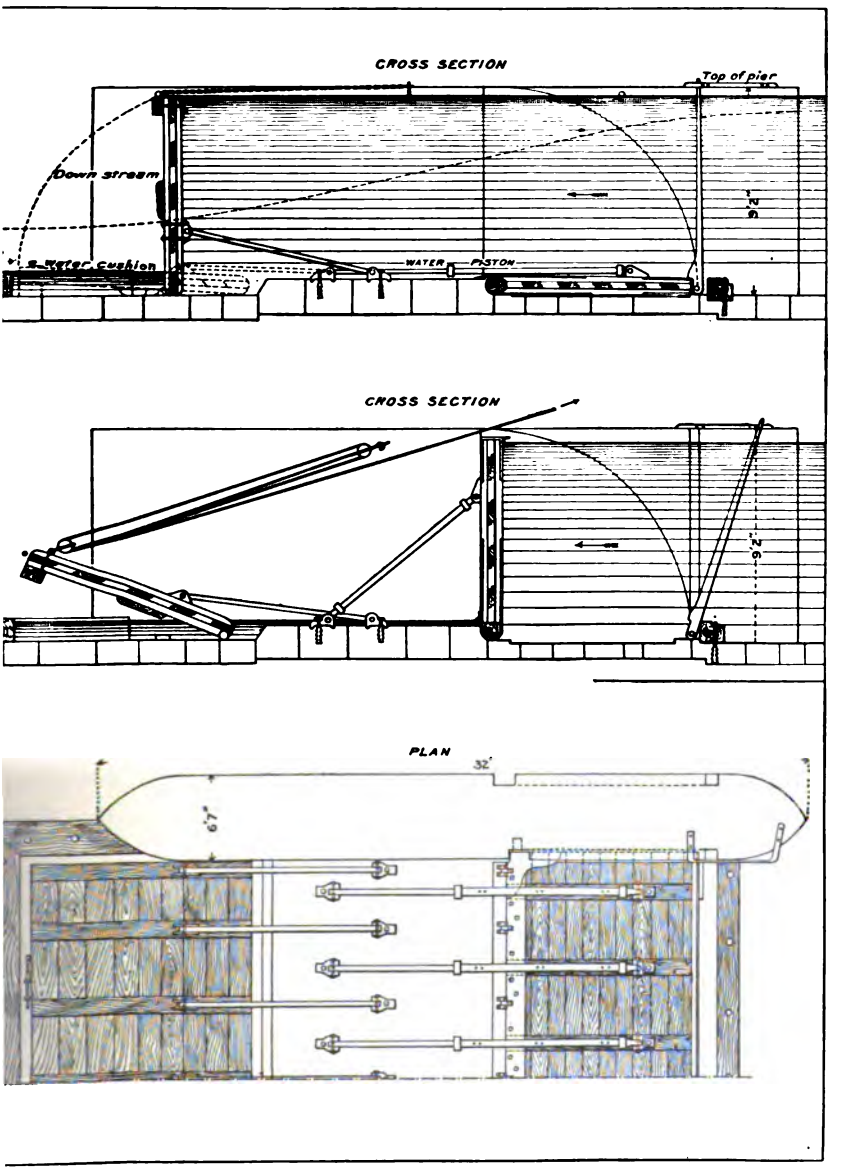


FIG. 25.—Soane canal, automatic sluice gate.

ing from 6 feet above the floor. The floor is 1 foot above the crest he weir, and as the needles on the top of the latter are designed to d up 7½ feet of water, 6½ feet can be forced into the canal. There

is nothing novel in this regulator, the gates being made of wood b with iron and sliding in cast-iron grooves. The lifting apparatus traveling winch working on rails on the top of the parapet of bridge, so placed that the drum of the crab winch is centrally over the gate to be lifted. There is an upstream set of grooves in piers into which planks can be inserted to relieve the gate from pressure should it jam. Planks are generally used for regulating supply in the canal, the gates being intended for use only when necessary to close the regulator quickly.

WELL FOUNDATIONS.

Wells and blocks may be considered as one and the same form construction, though perhaps blocks are more properly rectangular wells having one or more well holes in them, while wells proper circular in plan with a single central opening. They are in re brick caissons from 6 to 20 feet in diameter, the walls varying in thickness from 2 to 4 feet and of any required height. Blocks are regular brick caissons, perhaps 6 by 10 or 12 feet, with 2-foot or walls, and subdivided into two or even four vertical passages or holes. For the piers of the Solani aqueduct the blocks are square and divided into four well holes. At the head of the A canal they are rectangular, 13½ by 9 feet, and contain two well each 4 by 3 feet. At the head of the Lower Ganges canal they round, 12 feet in diameter, with walls 2 feet thick.

In sinking wells the water in the part of the river to be open upon is usually temporarily dammed and the earth removed un water surface is again reached. Curbing of bamboo of the size well is then laid, and on this the well is built up. It is commenced placing on its lower edge a cutting surface of wood or iron, w shaped, with the cutting point downward. Into the top of this masonry work is built. As the building continues the sand and are removed from within by hand or by dredge, and the well sinks its own weight. Much difficulty is frequently encountered in these wells, owing to their uneven subsidence or on account of ing layers of earth of different character, which must be remov the well so loaded as to cause it to sink vertically. When the w block is sunk to the required depth it is usually filled with co and thus becomes a solid pillar. The spaces between the walls then protected by sheet piling, and after the removal of the sand crete is placed between them, thus forming a continuous wall. method is simple and not costly. It is particularly effective in sand or in quicksand, and may be carried on by workmen with risk of danger.

The depths to which wells are sunk differ greatly. In the c the head-works of the Agra canal no wells whatever were made the weir, as it rested directly on the sand. At the head of the S

SINKING FOUNDATION WELLS, NADRAI AQUEDUCT, LOWER GANGES CANAL.

al the wells are sunk about 10 feet below the base of the weir; and Narora, at the head of the Lower Ganges canal, they were sunk 20 ;. Wells are built either in single or double rows, the distance ween these varying according to the dimensions of the wells them-ves. They have in some cases been connected by brick masonry hes, and the interspace below the arch filled with solid brick. This ı done in portions of the head-works of the Lower Ganges canal. 'he most striking case of the construction of wells as a foundation a masonry superstructure is that of the wells for the support of Nadrai aqueduct on the Lower Ganges canal over the Kali Nadi 'rent. The whole structure of the aqueduct, including river and al wing walls, is founded on wells, the cutting edges of which are k 51½ feet below the level of the Kali Nadi Torrent at that point, average depth of the wells being 56 feet. The wells are of three ;s, being 20 feet in diameter for the piers and canal land wings, 13 ; in diameter for the river piers, and 12 feet for the abutments. ;re are 102 wells 20 feet in diameter, 44 wells 13 feet in diameter, l 122 wells 12 feet in diameter, or a total of 268 wells on this work. ; total linear depth of well sinking amounted to 15,008 feet. Accom-ıying are given illustrations showing some of the details of these ls (Pl. XIV).

'he well curbs were generally constructed of wood, with wrought-ı bolts 1¼ inches in diameter projecting from them and built up ɔ the brickwork. In the 12- and 13-foot wells only one dredger was :ked at a time, and the average rate of sinking was 1 foot per day. the 20-foot wells three or four dredgers could be used at once, and h this number the rate of sinking amounted to 1¾ feet per day. ilding and sinking went on alternately in the construction, the ckwork being carried up in lengths of about 8 feet, as the wells ;k that much. When 25 feet had been sunk the brickwork was ried up the full height, 47½ feet above the cutting edge, and the king continued until clay was reached. On a well showing even slightest signs of going out of the perpendicular dredges were rked on the opposite side from that to which the well inclined. In reme cases a "jham" was worked from a windlass on top, which :red up the silt in the sump less than did the dredger and allowed eeper hole to be made on one side. Only two or three of the 20-ɔt wells were 1 in 40, and the majority less than 1 in 100 out of 'pendicular when the under dredging was stopped. In the lines of ; abutments, where the 12-foot double rows of wells were only 2 feet ırt, there was a decided tendency for each pair of wells to lean toward ;h other and for the curbs to separate. In some cases where the lls got out of perpendicular or failed to sink in the hard clay, it came necessary to load them with railway iron or a temporary perstructure of brick. To test their resistance against subsidence ne of the less satisfactory wells, after they had been hearted with

concrete, were loaded with a great temporary superstructure of bri[illegible] which in the case of one well weighed 1,451 tons (Pl. XIV). [illegible] total subsidence amounted to but 1¼ inches. After the well had [illegible] through the blue clay and while dredging in the brown sand was [illegible] progress, inblows of the blue sand above the clay were of freq[illegible] occurrence. These were generally caused by the dredger being work[illegible] awkwardly. Sometimes the inblows were so rapid as to bury [illegible] dredger before it could be lifted, and at other times they w[illegible] extremely gradual. These inblows frequently caused the well [illegible] incline from the vertical. When it was found that some of the [illegible] foot wells inclined from the vertical, advantage was taken of it [illegible] make them incline, so that when finally loaded with the superstructure and arch they would be in the best position to receive the arch thrust.

Mr. Beresford, the superintending engineer, in a note on "Friction resistance to sinking due to lateral pressure of earth on the side[illegible] well,"[a] shows that the pressure Py exerted by earth against a ver[illegible] plane per unit of the breadth is

$$Py=\frac{Wx^2}{2}\cdot\frac{1-\sin O}{1+\sin O},$$

where W=the weight of earth per cubic foot, x=the depth [illegible] plane is sunk below the surface of the earth, and O=the ang[illegible] repose of earth. The values found practially agree very closely [illegible] those derived from this formula. From some computations it was [illegible] that the value of $Py=\frac{100}{2}\times 58^2\times 0.33\times 63=3,496,878$ pounds=[illegible] tons, taking W=100 pounds; O=30° and the coefficient of fricti[illegible] the masonry on moist clay as given by Rankine=0.33. Therefo[illegible] friction F=1,562×0.33=515 tons.

ESCAPES.

In order to establish a complete control over the water in a [illegible] channel, provision is made for disposing of any excess which may [illegible] from sudden rains or floods, or from water not being required for [illegible] gation. This is effected by means of escapes or short cuts from [illegible] canal to the river or other natural waterway into which the exc[illegible] the water can be discharged. These escapes perform the additi[illegible] service, in the case of streams carrying much sediment in suspen[illegible] of flushing the canal, thus preventing or removing excessive [illegible] deposits. Colonel Cautley, in speaking of escapes and their em[illegible] ment on the lines of distributaries, says:

> In times of flood, opening the heads of the distributaries relieves the [illegible] canals, and the former are in turn relieved by the escapes. Hence the dis[illegible] tary heads become the safety valves, and the escapes the waste pipes of the [illegible] canal system.

[a] Gordon, W. B., Notes on Well Sinking, Nadrai Aqueduct, Public Works Department [illegible] west Provinces, India, p. 20.

Escapes are provided at certain intervals along the entire canal line, d a double set of regulators are made at the point where the escape taken off, as in the case of a branch canal or distributary. On the nges canal they are projected at every 40 miles, though much pends on the convenience with which they can be made and the proxity of the canal to some water course into which the escape water n be conducted. They are also provided if possible at dangerous ints, as above or along lines of heavy embankment where, in case the bursting of the bank, much damage would ensue. The first main ape is always constructed at a distance of half a mile or less below e canal head, and when it becomes desirable to scour out the silt cumulated between the head and the escape the latter is opened and arge volume of water admitted to the canal. This runs off through e escape carrying the silt with it. It is usual in such cases to decrease e slope of the canal for a short distance below its head to cause the posit of matter carried in suspension between that point and the ape.

The escape cut must be sufficiently large and have enough fall to rry off the whole body of water which can reach it, so that if necesry the canal below the escape may be left dry for repairs without pping its running above. The complete control of the canal waters double escapes consists of the construction of a regulator at the ad of the escape, and another one across the canal channel immeately below the escape. These escape heads are similar to the reguing bridges previously described and to the various regulators conucted at the heads of distributaries. When a heavy rain occurs on e line of a canal the irrigators cease to use the canal water, and as e flow can not be immediately stopped at the head-works, great dame would be done by the surplus water but for the escapes, which act though the head regulator of the canal had been brought so much arer the point of application.

The Khutowli escape head on the Ganges canal is an interesting ample. It is at the sixty-second mile and consists of a channel excated 60 feet wide and 3½ miles long. The masonry head consists of n openings, each 6 feet wide, the height from the flooring to the ffit of the arch being 8½ feet. The flooring is 64 feet wide, 40 feet which forms the tail, and is laid on a slope of 1 foot from the level the canal bed. The banks of the works are protected by masonry vetments and guards of piling and rubble which protect the floor om the wear and tear of the current.

Colonel Cautley made the following rules to control the location id regulation of escapes on the Ganges canal:

With reference to position, the distance between the escapes is limited to 40 iles, considering that by adapting their capacity to the volume of water contained this length of canal the facilities for regulation are ample. In the sandy tracts the canal the number of the escapes is multiplied rather than having their waterıy increased. The sites of all escapes are fixed in such a position that the

water may be plunged into the bed of the receiving channel and that the high water mark of the latter shall never interfere with the free discharge of the canal. The escape channel shall, when perfected, have, in addition to the initial slope of 12 inches from the bed of the main channel which is given to the tail of the escape head, a slope of bed equal to 1½ feet per mile.

FALLS AND RAPIDS.

As the natural fall of the country through which a canal runs is usually greater than the slope of the canal, it becomes necessary to compensate for this difference of slope. This is done by concentrating it at a few points where vertical falls or rapids are introduced.

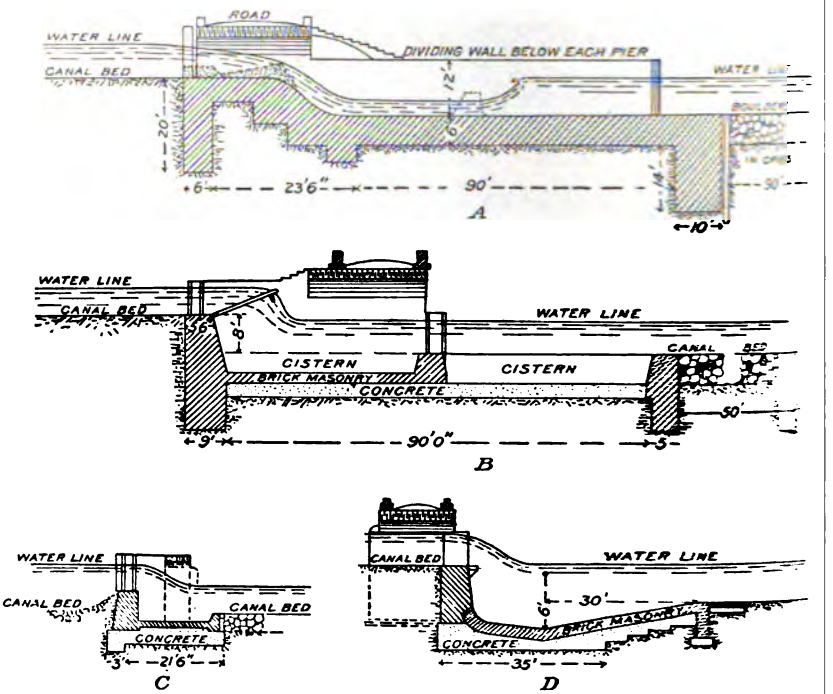


FIG. 26.—Sections of canal falls.

The location of these is usually fixed by the place where the canal becomes too high above the surface of the ground, while their exact position is made to coincide if possible with that of a bridge or similar work in order to economize masonry construction.

Ogee falls were first adopted on the Ganges canal and are of the shape shown in the accompanying figure, the intention being to break the force of the fall of the water. They were about 8 feet high. But the shock of the fall proved so great that they have been modified to give two vertical falls, the lower of which drops into a water cushion. On the Ganges canal were a number of ogee falls (fig. 26, A) 15 feet high. These have been so remodeled as to give an upper fall of 5 feet, the

ASAFNAGAR FALLS, GANGES CANAL.

hort level bench of 10 feet, and a vertical drop of 10 feet, ending a shallow water cushion (Pl. XV). These falls have a solid sonry floor 4 feet thick. On some falls the action of the water is sened by making it play over a wooden grating. This reduces the ock by dividing the stream into a number of fine threads. Falls invariably constructed of substantial masonry laid on a deep and n foundation. The banks are protected by masonry and paving. e latter is carried for some distance below the fall both in the bed d on the sides, and the flooring terminates in a row of sheet piling. broad canals like the Ganges the fall is generally divided into comrtments by longitudinal dividing walls, so that when repairs are cessary one portion may be laid bare at a time. On the Ganges ual most of the falls are constructed at points where bridges would necessary, and to the lower side of the bridge the fall is attached. low this the channel of the canal is widened out, the flooring and es to the extremity of the cistern in which the fall terminates being efully and securely paved and revetted.

Experience seems to show that vertical falls with gratings, as used the Bari Doab canal, and terminating in water cushions, are the st that have been devised (fig. 28). The grating consists of a numr of wooden bars, resting on an iron shoe built into the crest of the l, and on one or more crossbeams, according to the length of the bars. ese bars are laid at a slope of 1 on 3, and are of such a length that e full supply water level in the canal is half a foot below their upper ds. The dimensions of the bars used where the depth of the water 6½ feet are as follows: Lower end one-half inch broad by threeurths of an inch deep; upper end one-fourth inch by three-fourths ch deep. They are supported on beams 1 foot broad by 1 foot deep. first these beams were 6 inches apart, but it has since been found st to increase this distance a trifle, and now 18 bars are placed in a -foot bay. The bars are undercut from the points where they leave e shoe at the crest of the falls in such a manner as to make each ace an orifice in a thin plate.

The effect of a fall at the end of a canal reach is to increase the locity and to diminish the depth for some distance above the fall. is increase of velocity produces a dangerous scouring on the bed d banks of the canal, and is guarded against by heading the water at the crest of the fall by means of sleepers dropped in grooves of e piers, thus increasing the height of the fall. The narrowing of e canal banks at the fall produces the same effect. The better ethod, however, is to raise the crest of the fall by a masonry weir, d the height necessary to raise it is found by the following calculaon, given by Colonel Dyas:

$$H=\left(\frac{900\,a^2\,d}{l^2\,s}\right)^{\frac{1}{3}}-125.8122\frac{d}{s}$$

which H is equal to the height of the water above the crest of the

fall; a is equal to the sectional area of the open channel; d equals the hydraulic mean depth of the same; l is equal to the length of crest of the fall, and s equals the length of slope to a fall of one in same. When gratings are used these act instead of a weir in checking the velocity of the water, and the method of spacing them is such that the velocity of no one thread of the stream shall be either increased or retarded by the proximity of the fall.

On the Soane canal, where there are many locks, the falls are nearly always introduced at the points where the locks occur (fig. 27). The main line is carried through the locks, and the waste weir or branch channel is carried around them, and in it the surplus water over that which is required for the operation of the lock is conducted. In the branch channel a fall must be constructed. In one case noticed, where there were two locks, with a total lift of 20 feet, the fall was constructed

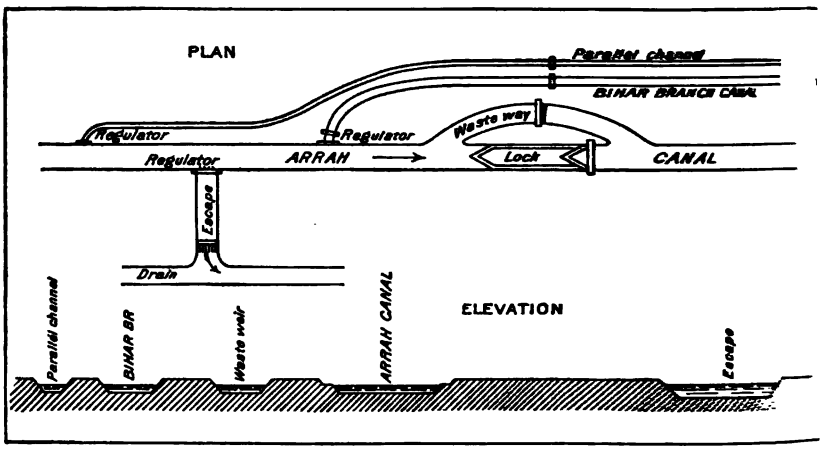


FIG. 27.—Soane canals, Bengal; arrangement of branches and escape at Dunwar.

in three bays. The channel was 40 feet wide and the falls were built of substantial brick masonry terminating in a deep cushion below. On the Agra canal are several interesting falls, perhaps the most elaborate of which is the Kushuk fall, on the Bata escape (fig. 30). This is a masonry fall, or rather two falls terminating in water cushions, the total height of which is 27 feet. The total length of the masonry work is 190 feet, and the depth of the concrete flooring is 3 feet, terminating on a well, on which the toe of the apron rests.

Instead of falls, rapids have been constructed with great success on the Bari Doab canal (fig. 28). The slope of the rapid is paved with large bowlders, confined by walls of masonry built at intervals of 40 feet longtudinally across the stream. From experience on these rapids has been found that dry bowlder or rockwork is not to be depended on for velocities over 15 feet per second, and that over this the slope must be modified or masonry be used. On the Bari Doab canal rapids were adopted wherever bowlders were procurable at moderate expense

Bowlders form the best material for the flooring of a rapid. Brick-ork should not be used with currents of high velocity, as the best icks do not stand the wear and tear for any time, certainly not for rvice in contact with velocities exceeding 10 feet per second. The owlders were generally grouted in a good bed work of mortar and all pebbles or shingle, where velocities above 15 feet per second ere employed. The tail walls on these rapids are of peculiar con-ruction, for the purpose of turning back the eddies and of protect-g the canal banks from the direct action of the water. Beyond a oint where the heaviest action occurs and where the greatest width given the tail-works, the banks incline toward each other so as to rect the set of the stream to the middle of the canal. The tail walls e not kept to their full height throughout, but gradually become wer and lower, till they disappear altogether, where they reach the me level as the bed of the canal. In case no tail works are given, e banks are faced with bowlders or piling for a length of perhaps 0 feet below the rapid. On distributaries and their branches falls d rapids are resorted to, as on the main canals, differing only in tails of design.

DRAINAGE WORKS.

In canals where the diversion line is carried along the sides of hills slopes, great difficulties are sometimes encountered in passing the de drainage which crosses the canal lines. Much can be done by iverting water courses or constructing short drainage cuts emptying to natural drainage lines. When the drainage can not be diverted may be passed in one of several ways. If the stream is at a lower vel than the canal the latter may be passed over it in an aqueduct, hich in most cases will involve the construction of some embank-ents before the stream channel proper is reached. If the canal and ream meet at the same level the latter may under exceptional circum-ances be permitted to enter the canal. This will necessitate the intro-uction of proper regulating works below the canal crossing, and an scape or dam on the opposite side to the inlet. In the case of very mall streams entering a canal at level, an inlet only is necessary, the urplus water being passed off through the first escape in the canal hannel. If the stream encountered is at a higher level than the anal it is generally carried over the latter in an aqueduct, which is alled a superpassage. In the case of nonnavigable canals, less elab-rate drainage methods than those described may be employed, and odifications of these methods are used, as when the canal is carried nder the stream in an inverted siphon, or a combined siphon-aque-uct has been constructed.

By means of simple diversion of the course of a stream much xpense may be saved. An instructive example of diversion is that f the Chuki Torrent on the Bari Doab canal. At the time of the onstruction of the canal this torrent had two outlets. Just above the

crossing of the canal the main channel divided, one channel running into the Beas and the other into the Ravi River. The latter was embanked close to the bifurcation by bowlder dams and spurs protected by masonry revetments. By this means the whole of the water was forced to flow into the Beas, and the expense of the work of crossing the canal was saved. Another instance is that at the head of the Betwa canal. The first 6 miles of this is protected by a drainage channel 15 feet wide at the bottom and 6 feet deep, which runs parallel to the canal and carries the drainage into a small stream whence it is let into the Betwa River. At the Betwa head-works a creek enters the river, and this was blocked up by a large embankment and turned back by a cut, through which it entered the river above the head-works.

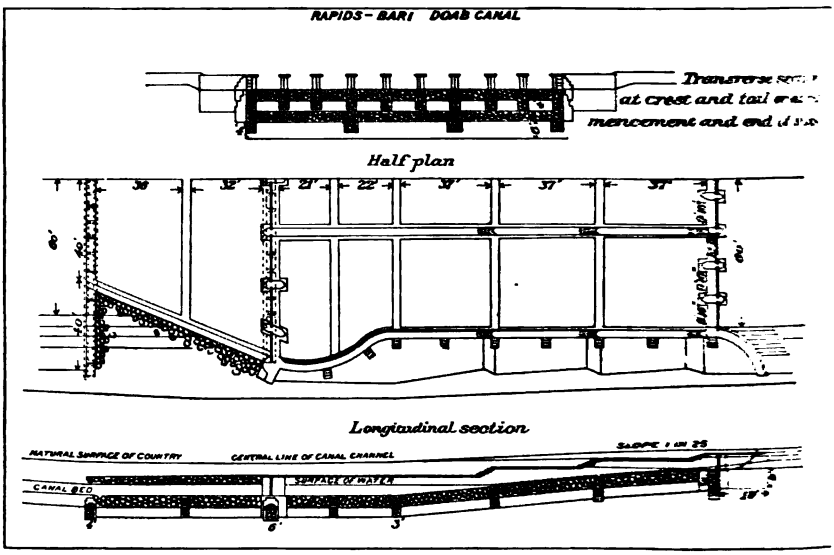


FIG. 28.—Rapids, Bari Doab canal.

Aqueducts differ from bridges only in having to carry a waterway instead of a railroad or roadway. The bridge portion may be wood, iron, or masonry. In India, masonry is almost exclusively employed because of its relative cheapness and permanency. On the Soane canal are several interesting aqueducts, one of which, at the Thora Nulla, carries the Buxar branch canal on a well-constructed masonry structure (fig. 8, p. 102). This aqueduct is 38½ feet in height and, exclusive of the wings or retaining walls, is 155 feet long, the width exclusive of wings being 54 feet. The waterway of the aqueduct is 42 feet wide on top, 40 feet at the bottom, and 7 feet in depth. The waterway for the torrent beneath the aqueduct is constructed also as an inverted siphon, the bed having an inverted arch beneath the piers. There are four spans, each 30 feet wide by 20 feet 9 in

SOLANI AQUEDUCT, GANGES CANAL.

h, the arch above supporting the aqueduct. The height of the s to the springing of the arch is 12 feet and the rise of the arch feet. The piers are each 6½ feet wide. The object of the invert that should a greater flood occur than is estimated for, the open- s may act as siphons. They are estimated to carry 10,000 second- .

ne of the greatest and earliest aqueducts constructed is the Solani educt on the Ganges canal at Roorkee (Pl. XVI). This consists an earth enbankment 2¾ miles in length across the Solani Valley, l about 16½ feet high, its greatest elevation above the river bed ng 24 feet. This embankment, as shown in the sketch (fig. 29), 50 feet wide at the base and 290 feet wide on top, and on this the al banks are formed. The outer edges of these banks are 30 feet e and 12 feet deep, and are lined throughout by masonry or revet- nts of stone. The exterior slopes of the embankment are 1 on 1½, l have been made with great care. The total length of the upstream etted channel is 10,713 feet; that of the downstream channel is 23 feet, and between these embankments is built the masonry educt, the total length of which is 920 feet, with a clear water

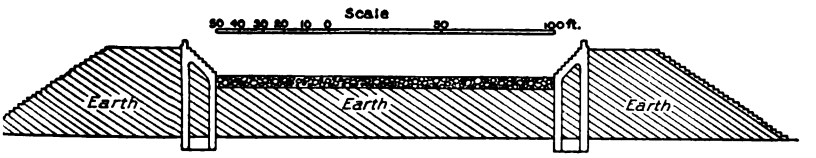


FIG. 29.—Cross section of Solani aqueduct, Ganges canal.

ce between piers of 750 feet in length, consisting of fifteen spans 50 feet each. The breadth of each arch parallel to the channel of river is 192 feet and its thickness is 5 feet. The arch is in the m of a segment of a circle with a rise of 8 feet, and the piers are sed on foundation blocks of masonry, sunk 20 feet in the river bed. e greatest height of the aqueduct proper above the river valley is feet. The waterway of the aqueduct is formed in two separate nnels, each 85 feet wide; the outer walls of masonry are 8 feet ck and 12 feet deep, the aqueduct being intended to carry 12 feet water. The velocity through the aqueduct is 3⅔ feet per second.

Perhaps the most magnificent aqueduct yet constructed is that built ross the Kali Nadi at Nadrai, which carries the waters of the Lower nges canal over that river. The first aqueduct at this place was ch smaller than the present one. Before the great flood of 1885 it s calculated to permit the passage of 30,000 second-feet through the e bays into which this water way was divided, and it was founded the natural channel of the torrent. In 1884 an extraordinary flood curred which discharged nearly 100,000 second-feet under the aque- ct, and greatly injured it. Repairs were at once commenced and ght alterations made in order to increase the channel. On the 2d of

October, 1884, a flood level was noted on the upstream side corresponding to a reading of 22.2 feet on the downstream gage, the difference of surface level above and below the aqueduct being 3½ feet. The mean velocity of discharge in this flood was about 10½ feet per second. This work had scarcely been commenced when, on the 17th of July 1885, another and greater flood occurred. This flood is fully described in notes made at the time by the executive engineer, Mr. W. Good.

Early on the morning of the 17th the river began to rise and the water level rose in a wave 4 feet high and carried away part of the revetment. Other waves 10 or 15 feet high surged over it, and the whole of this revetment work and the abutments collapsed. Shortly afterwards the piers were carried away and parts of the aqueduct fell into the stream. The velocity was terrific. The water in the main stream was piled up in waves 20 feet high at intervals of 100 feet apart. By 3 in the afternoon 100 yards of the canal bank had been carried away and all of the aqueduct had been destroyed. From 4 o'clock in the morning to 3 o'clock in the afternoon the level of the water rose a total height of 23 feet and had a velocity of over 18 feet per second. From estimates made by Mr. Good the discharge of that flood was probably 135,000 second-feet, and during the rain storm (which lasted three days), an average of 22 inches of rain fell on the whole catchment area. The greatest fall occuring in one day, the 16th, was [illegible] inches on some portions of the basin.

In estimating for an aqueduct to replace the old one, this flood was considered as the greatest which was ever likely to occur, and the aqueduct as now finished is estimated to discharge under it [illegible] second-feet, with a velocity of 8 feet per second, thus requiring a waterway of 22,430 square feet. This is equivalent to a run-off of [illegible] cubic feet per square mile of catchment, the total area of which is 3,025 square miles. The waterway for the canal on top of this aqueduct will carry 3,175 second-feet.

The aqueduct (fig. 33) consists of 15 masonry spans, each [illegible] long, supported on wells. The maximum pressure on the foundation wells of the piers does not exceed 2½ tons per square foot. Under the aqueduct is sunk a concrete floor 5 feet in thickness. The total cost of this work was about $1,523,000.

On the Ganges canal are two of the largest as well as the most interesting superpassages constructed in India, one for carrying the Pur Torrent and the other the Ranipur Torrent over the canal. In the construction of a superpassage especial care must be taken to give it such a slope that it shall not be filled up by the deposit of sediment while the masonry and revetting of the banks must be carried a sufficient distance on each side of the canal up and down stream to protect the foundations of the work.

[a] Failure of the Kali Nadi aqueduct: Records of the Government of India, Public Works Department, No. 240, Calcutta, 1888.

RANIPUR SUPERPASSAGE, GANGES CANAL.

The catchment basin of the Ranipur Torrent is about 45 square miles, average width being 4½ miles and its total length 10 miles. At the int where the superpassage is constructed there is an ogee fall with lrop of 9 feet, the base between the piers supporting the superpasge being used as a portion of the masonry construction of the fall l. XVII). The foundations of the upper and lower levels are proted by lines of piling and box work; the former have a width of 10 et and the latter of 70 feet. The flooring of the superpassage from e crown of the arches to its bed is in its thinnest place 3 feet thick, d the parapets are 7 feet wide and 4 feet high. These continue land from the body of the work a distance of 100 feet on each side, panding outward so as to form wings for keeping the water within unds. This superpassage is 300 feet long and provides a waterway r the torrent 195 feet wide and 6 feet deep.

At the Puthri superpassage the torrent of that name drains an area about 85 square miles and discharges a maximum flood of 15,000 cond-feet. This superpassage consists of an aqueduct, under which e canal passes in nine bays, each 25 feet wide. The width of the perpassage is 296 feet. This waterway, as it now appears, was made o wide, and accordingly the decrease in the velocity of the torrent this point, which in the natural channel is 16 feet per second, has used considerable silting and the superpassage has been constantly ling up. This error has been obviated by decreasing the waterway the construction of masonry groins projecting from the side parats of the superpassage out into the stream at right angles to its urse. This has nearly remedied the evil, as the silt previously posited is now being rapidly cut away.

The Sasoon superpassage (fig. 36) on the Sirhind canal, whereby e Sasoon Torrent is carried over the canal, drains an area of 24 uare miles. The discharge of this stream is estimated at 7,750 cond-feet, and a waterway has been provided 150 feet wide by 6½ et deep. The difference in level between the bed of the canal and e torrent is 21.9 feet, of which 7 feet are depth of water in the nal, 10 feet headway up to soffit of arch, 3 feet the thickness of the ch, and 1.9 feet brick flooring. The canal channel is spanned by ree central arches, each of 45 feet span, and two at the sides, each 32 feet span. There is an aggregate waterway for the canal of 184 et, but the mean waterway of the channel is only 177 feet. The le walls or parapets of the superpassage are 10 feet high and 5 feet ick at base. The mode of construction of this superpassage is indited in fig. 36, p. 149.

An interesting mode of disposing of drainage is by a drainage servoir, as is done on the Agra canal. Several streams cross the nal at a certain point. They are, however, all disposed of through e channel by constructing an embankment on the upper side of the nal, so that a reservoir is made. The object of this reservoir is not

storage, but drainage. The embankment is of earth and about [illegible] feet high. The bottom or sill of the superpassage, which carries the flood water over the canal, is about [illegible] feet above the bottom of the reservoir, the object being that the lower 20 feet of the bed of the reservoir can be cultivated and supplied from the water. A large revenue is returned to the government from the lands cultivated in the reservoir bed after the waters have been drawn down through the superpassage. This superpassage is constructed of boiler iron. It is [illegible] feet long, 30 feet wide, 10 feet deep, cross braced by angle iron on top, and supported by two piers each 5 feet thick. It is well built and supported and the slope is steep, giving a high velocity to the water. The connection between the ends of the superpassage and the abutments is made of heavy sheet lead, to accommodate the changes due to expansion of the iron and to prevent leakage. As flowing through this superpassage the water falls vertically 12 feet, and then 25 feet into the old channel of the River Jumna.

FIG. 30.—Agra canal, cross section of Kushuk Falls.

The Rutmoo Torrent is passed across the Ganges canal by a level crossing (Pl. XVIII). This consists of a simple inlet at the torrent entrance to the canal and of a masonry or dam and escape regulator in the canal bank opposite the torrent inlet, where there is another regulating bar across the channel just below the inlet (fig. 31). By this means the flow of water is easily regulated, the amount admitted to the canal being the inlet being controlled by the regulator in the canal itself and the superfluous water being discharged through the regulating breach or dam in the canal bank. This dam consists of 47 sluice ways, each 10 feet wide, with their sills flush with the canal bed. These are flanked on either side by overfalls of the same width

RUTMOO LEVEL CROSSING, GANGES CANAL.

their sills, 6 feet higher, and on the extreme flanks are platforms et above the canal bed. These elevated platforms are 17 feet long connected with the revetment on the canal banks by inclined planes asonry. This escape dam is practically identical in construction the ordinary scouring sluices at Myapur and other places. The rway through the sluices up to the height of 6 feet is 470 feet wide, between the levels of 6 and 10 feet it is 570 feet wide. Above that 800 feet wide. The closing and regulating of the opening in this eway is conducted by means of flash boards fitting into grooves. sluice gates are dropped rapidly, being constructed on a plan simi- to the Soane scouring sluices, but more crude in their method of ipulation. When not ood, the water in the ent is carried under canal and returned he Rutmoo Torrent w it by means of a e drainage tunnel or rted siphon about feet long. Owing the high velocity of floods in the Rut- Torrent, there is no osit of silt in the al, the greater part the silt being carried ight through it by rush of the flood ters. The torrent in years has been cut- g badly on the down- eam, and to stop this rogression of levels 5 sonry bars have been t across it, each about yards apart. These are composed of cribs filled with bowlders, d have acted as contemplated. The maximum flood anticipated d discharged through the Rutmoo Torrent is 25,000 second-feet. e regulating bridge across the canal below the crossing has 10 terways, each of 20 feet, and in addition to this there is a roadway er it forming a bridge. There is about a mile of revetment walls, resting on blocks or wells sunk to a depth of 20 feet below the nal bed. This is protected by numbers of piles and cribs filled th bowlders.

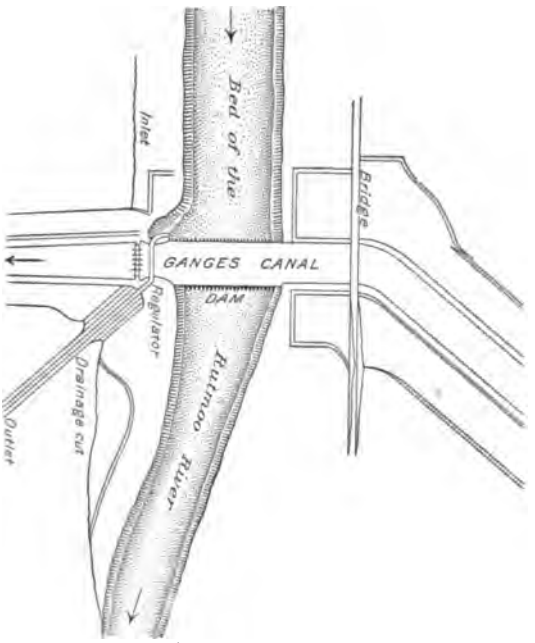


FIG. 31.—Plan of Rutmoo crossing, Ganges canal.

The Kao Nulla on the twenty-first mile on the main western Soane nal is passed by a siphon aqueduct. This torrent is subject to eat floods. They are estimated on the basis of 6 inches of run-off

on the 57 miles of catchment, and the highest velocity is 8½ feet per second. The siphon passage for the flood provides 1,103 square feet of water way disposed in 20 openings, each of 54 square feet. The work consists of substantial masonry carried well beneath the ground under the bed of the torrent and above ground for the support of the aqueduct, and is only a semisiphon carried under the aqueduct as indicated in the accompanying sketch (fig. 32). A similar work

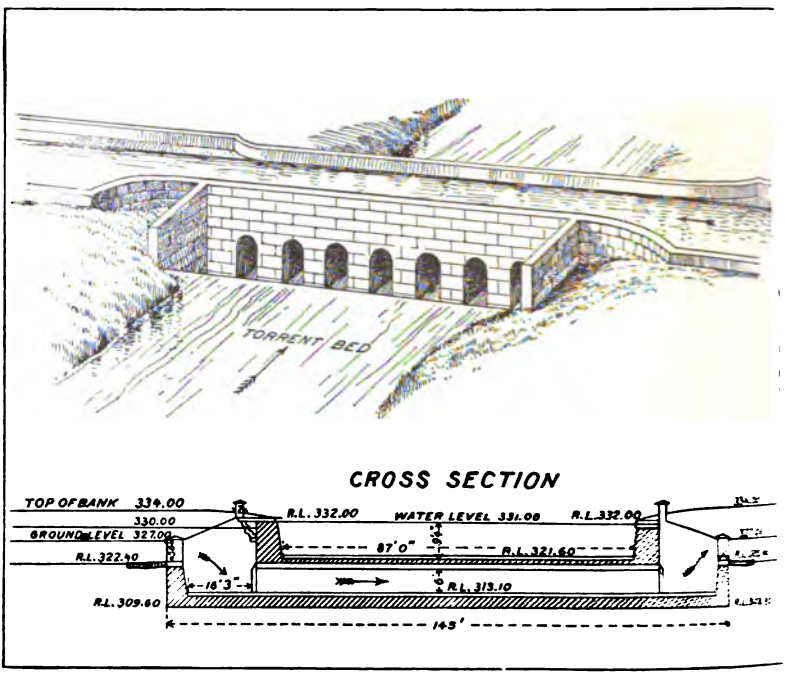


FIG. 32.—Kao Nulla siphon aqueduct, Soane canal.

that of a superpassage and siphon on the line of the Nira canal whereby the torrent is carried over the canal, the latter being an inverted siphon. This work is indicated in fig. 46 (p. 171).

DISTRIBUTARIES.

Like the main canals, the distributaries or laterals are invariably designed and laid out by and are under the control of the canal engineers. From these the farmers take their private water courses and channels to their fields. Sir P. T. Cautley thus speaks of them in connection with the Ganges canal:

> In our irrigation system the trunk and main canals with their great heads play the part of a reservoir to the distributaries. The latter hold the relation of the main canals of a system of distributary pipes in a town water supply; the village or private water courses play the part of service pipes.

Distribution from a canal is most economically effected when the latter runs along the summit of a ridge so that it can supply water

branches and to private channels on both sides of it (fig. 37). is location in the case of a large canal can happen only in occa- nal instances, but the secondary or distributary branches taken m these principal canals can and should be made to conform to

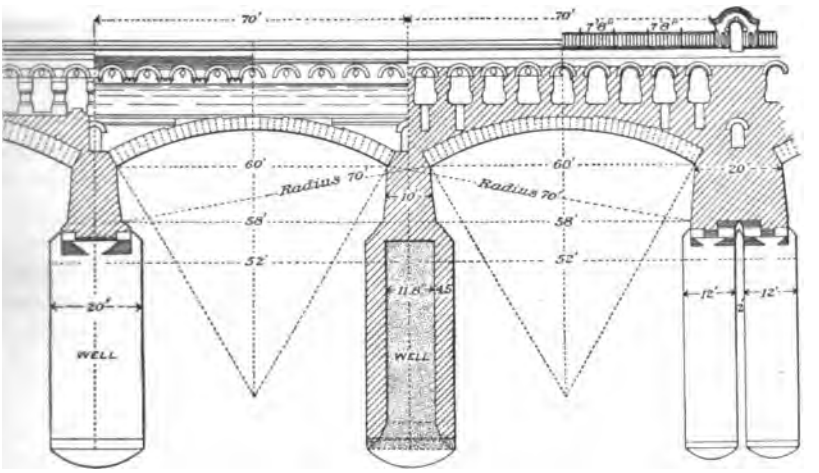


FIG. 33.—Nadrai aqueduct, Ganges canal.

iding lines between water courses. The capacity of the distribu- y which then traverses each separate drainage divide is propor- ned to the duty it has to perform, the bounding streams limiting area it has to irrigate.

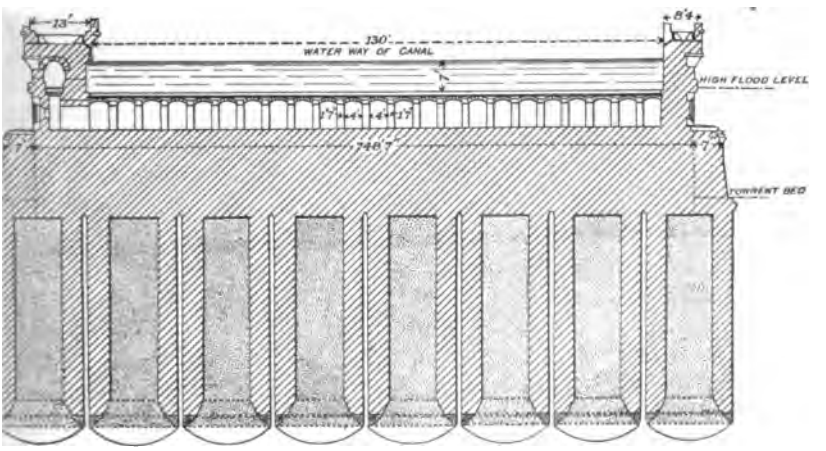


FIG. 34.—Cross section of Nadrai aqueduct, Ganges canal.

For the more complete and efficient distribution of water the engi- er treats them as of as much importance as the main branches omselves. Attention is devoted to the character of the soil trav- ed, to the alignment, to the safe and permanent crossing of nat-

ural drainage lines, and to so maintaining the surface of the ca with relation to the ground as to command the largest irrigable ar In all well-designed distributary systems the capacity of the chan is exactly proportioned to the duty to be performed, the cross-sectio area being diminished as the quantity of water to be carri decreased owing to its diversion by private water courses, thou sufficiently large margin is usually allowed for future pos development.

It is usual to take off the water of a distributary from the m canal as near the surface of the latter as possible. That is, the b of a distributary should not be on a level with the bed of the m canal, the object being first to get the clearest water possible, wh is found nearer the surface, and second to keep the bed of the tributary at as high a level as possible to admit of surface irrigat throughout its length. In level country great care is always ta in designing these distributaries that the natural drainage lin which they tail shall be sufficiently large to accommodate any volume it may be necessary to pour into them, so that the distr tary may be rapidly relieved during times of storms and the drai lines shall not become clogged and flood the surrounding cou The slope of a distributary is usually planned to be as nearly as sible parallel to that of the district it traverses in order to a costly embankments and to insure the surface of the water i above that of the country. Falls are sometimes rendered necess by the profile of the country, as is the case on larger canals, w escapes are introduced every 8 to 10 miles.

Distributaries as designed on the great Ganges canal have b made to conform as far as possible to a general design, which m outlined as follows: The heads have been constructed at the p where bridges or falls were necessary, in order to economize in ma construction. This location also insures their better inspection. beds are generally from 2 to 3 feet above those of the main canal which they are taken. These heads are designed as mere open ways with grooves for the introduction of shutters or planks further design has been attempted for the regulation of disch The distributaries are divided into main lines and feeders. Th or main lines run parallel to the canal on both sides, and these pa lines are met in their passage downward by feeders coming fro different distributary heads in the neighborhood. This princi constructing parallel channels to the main canal is one which not recommend itself for use in the United States, as the chief or rather the cause of their employment, has been the navig character of the main canal. As the main canal must necessarily a very low slope in order that the velocity will not impede navig and as these main canals at their heads below lock are usually some depth beneath the surface of the adjacent country, it be

actically impossible to distribute water from them, and accordingly e parallel lines have been employed, which, keeping near the surface the country, facilitate the distribution of the water to other minor annels. Where the canals are not primarily designed for purposes navigation these parallel channels may well be dispensed with, ough they are found on nearly all of the larger Indian works.

According to Major Brownlow, R. E., the greater the amount of ıter discharged by a distributary the smaller will be the proportion cost of maintenance, for a channel 12 feet wide discharges more an double that of two channels each 6 feet wide, while the cost of ıtrolling and repairing the banks will be half that of the two smaller ıes. Experience proves that irrigation can be most profitably car-ɜd on from channels 18 feet wide at the bottom and with about 4 et depth of water. On the eastern Jumna canal, during the years om 1858 to 1860, the expenditure on all the distributaries of 12 feet ıad width and upward was 0.123 of the revenue, while on all those ıow 12 feet it was 0.223 of the revenue, or nearly double the first. he relative value per cubic foot per annum from the same experi-ents, on channels of respectively 12, 6, and 3 feet in width, was as ı : 7 : 4. Increased action of absorption in small channels, with minished volumes and velocities, accounts for the difference. The ɜpth of water accordingly should be seldom less than 4 feet, and the ırface of the water should be kept at from 1 to 3 feet above that of ıe surrounding country, not only to afford gravity irrigation, but ɜcause the loss by absorption is thereby diminished. This was ıown in the experiments referred to in the previous part of this ıper, under the heading "Duty and absorption."

Indian engineers unite in condemning the practice of raising the ater in the channels to the surface of the country by means of dams stops made by introducing planks into grooves made for that pur-ose. This practice, they say, converts a freely flowing stream into a ɜries of stagnant pools, encouraging the growth of weeds, the deposit f silt, and an unhealthy condition of the neighborhood; and it is, ıoreover, extremely wasteful of water, since much of the latter is issipated because of the loss of head. In designing the canal banks ıe width of the top of the bank should be sufficient to admit of easy ıspection. On moderate-sized distributaries, such as those just eferred to, 4½ feet may be taken as the minimum width, and wher-ver the dimension of the channel will permit it this width should be ıcreased. Should the cutting be so deep that a berm is necessary, ; is always well to let the latter slope away from the canal and be rained off through the bank; the top of the bank, likewise, should lope away from the canal, and not drain toward it, as in times of ıeavy storms much silt may be deposited in the canal from this local lrainage.

Ordinarily the water for the village ditches is taken from the dis-

tributary by means of hollow wooden or iron pipes let into the bank of the canal and nearly flush with its bed. These are stopped at the outlet by a valve or plug. The heads of the distributaries on the modern canal systems are more carefully designed. They are usually constructed of substantial masonry works let into the canal bank and closed by a valve or other easily controlled shutter. In the North-west Provinces a series of standard designs has been prepared, an illustration of which is given (fig. 38). The heads of the minor branches or the private water courses are, like those of the distributaries, usually placed where the existing masonry works occur, as at falls or bridges, while the private channels head in simple wooden or iron

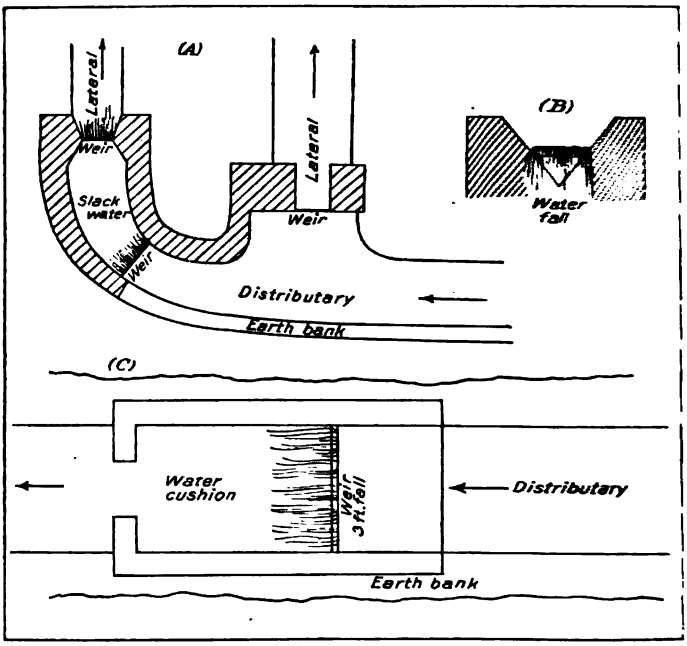


FIG. 35.—Plans of distributing head, Mutha canal, Bombay.

outlets. Substantial masonry falls are constructed at such points as the grade of the surface of the country makes necessary (fig. 35). These are usually simple vertical drops into a masonry well, and the scouring is generally lessened by creating a water cushion at the bottom of the fall.

In the Punjab and elsewhere rules have been laid down for the construction and estimate of the masonry works on distributaries. Among others are these: Siphon barrels shall have a sectional area equal to the bed width plus one-half the full supply. Siphon wells shall have the same area as above, the depth being equal to 1½ times the fall supply. The depth of the cistern at the foot of a fall in order to form a water cushion shall equal one-third of the height of the

is the full depth of the water. Thus with a fall 4 feet deep on a nal carrying 5 feet of water, the cistern depth will equal $\frac{1}{3}$ (4 + 5) 3 feet. The minimum cistern length is qual to three times the pth counting from the drop wall to the reverse slope, which latter l be 1 in 5. The width of the cistern must be twice the mean pth of the water in the channel, or twice the bed width plus the full pth.

While the water rate is at present charged in India according to the a irrigated and the crop raised, it is universally conceded that it uld be fairer to charge for the water according to the quantity used, it can make no difference to the canal proprietors what becomes of water after it has been delivered and paid for. The difficulties in way of delivering water by actual measurement have been insuperle, chiefly because no practical method of measuring water under

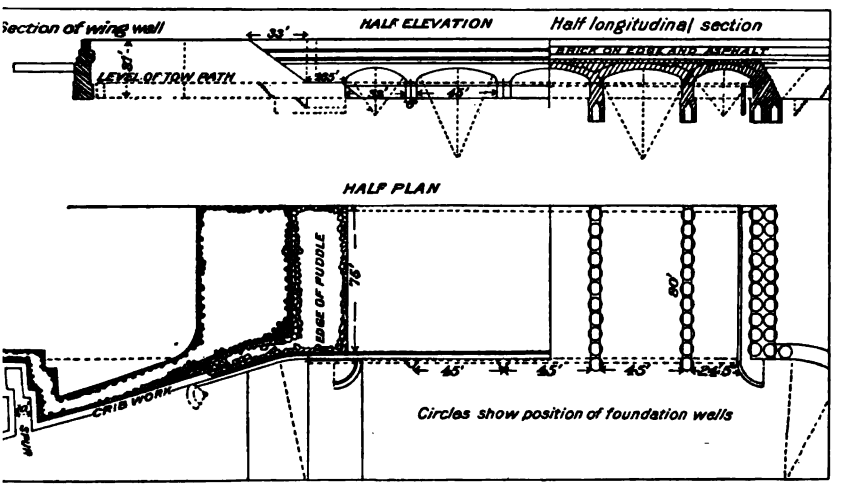


FIG. 36.—Sasoon superpassage, Sirhind canal.

constantly varying head has yet been devised. On all the olderstablished canal systems, especially when the supply entering the head f the canal is insufficient for the demand, a system called "tatil" as been established. This may in general be said to consist in a mode f regulating the amount of water given to the irrigators by the canal fficers closing their outlets for successive periods of time in regular otation. Each cultivator is compelled to take the water when his turn rrives, be it in night or day, or else lose his share of water at that ime. It is considered the best practice to impose these tateels on long ortions of a distributary at once, as short ones have very little effect n forcing water down to the tail of the canal. In their operation an rregular period of rotation is employed. Thus the outlets may be losed in the first length of the canal for four days, on the second porion for three days, and so on, and then this order may be reversed, the

period of rotation being such as to change the length of closure al[illegible] various portions of the canal. One advantage of the imposition [illegible] tateels is, that by affording a constant but moderate supply in the [illegible] tributaries the embankments are kept moist and are thereby less li[illegible] to crack, and the growth of weeds is to a certain extent checked.

The measurement of the quantity of discharge into any distributary is made by one of several methods. V weirs are usually constructed at the heads of these if the expense of the masonry will not be too great. Wherever falls or masonry head-works exist, V weirs can be cheaply added to the structure. For smaller channels standard-sized pipes let into the banks of the canal to draw off the water are used and the discharge through this orifice under a given head is known from experiment. In larger distributaries the volume discharged is usually obtained by measuring a short length of bank, and, knowing the cross section, the velocity is determined by floats on this known length. The methods in use are generally rather crude and unsatisfactory. For, though the sectional area of the outlet is known, little or no attempt is made to regulate the pressure. The majority of the larger outlets are masonry tubes, from 10 to 20 feet long, and the friction in these is considerable. The outlets are rarely so arranged that the pressure on the head can be regulated, as is done in the measuring boxes employed in California and Colorado. The Indian engineers hold that the ordinary Italian module is not applicable to their distributaries because of the fluctuation in the height of the main canal and because of the amount of silt carried in suspension, which clogs the tail and impedes the circulation of water.

METHODS OF APPLYING WATER.

There is little that is novel to American irrigators in the methods employed by the Indian agriculturist of applying water to crops. The chief peculiarity which at once strikes the observer is the great care with which each crop is handled and the expense with which the private ditches are frequently aligned and constructed. As India is an [illegible] country, and one in which both land and water are valuable, and the various individual holdings being small, each cultivator having but a few acres, rarely over 5, sometimes less than 1, to look after, it is a frequent occurrence to see the cultivators irrigating their crops from their ditches by means of wooden scoops or wicker baskets, with which they toss the water out of the ditch and scatter it over the land. In sugar cane, rice, and the more expensive grain crops the action of gravity is brought into greater play and private channels are so laid out that the natural flow of water will carry it over the crops.

In irrigating from wells the water which is raised is usually emptied into a basin or shallow tank excavated in the earth, which may be lined with puddle, or, as is frequently the case, with masonry. From this basin the water is conducted at first through masonry or wooden

ıstructed earth ditches to branch channels, which are ordinary run-
ys roughly excavated in the soil.

Rice is everywhere irrigated by dividing the land into small squares blocks in an irregular checkerboard fashion. These are usually t less than 20 and rarely 100 feet square, depending largely upon ırce of supply and slope of country. These blocks are separated low earth banks about 1 foot in height with cuts opening through ɜm from one block or field to another. Where the slope of the sur-ɜe is very light extensive fields may occasionally be seen within one ɔck. On hillside country the steeper slopes are terraced by the con-ˈuction along a contour line of a low embankment about 1 foot in ight. These terraces retain the water from floods or storms, sub-ɜrging the rice crop to a depth of several inches, thus acting as ıniature tanks. In the more level rice country the various blocks e flooded from the canals, the rice always being submerged to a nsiderable depth.

In irrigating sugar cane an effort is usually made to obtain a freer ɔw of water than can be obtained by the above method, though as in e case of rice cultivation this crop requires a great deal of water ıd it is permitted to stand to a depth of several inches over the sur-ce of the ground. Wherever the slope will permit, numerous cross ırrows are plowed or narrow ditches run throughout the field of ɜain or cane in such a manner as to permit the water to flow in a ıin layer over the soil, that which is not absorbed being caught up nd utilized by the next lower ditch. Excepting in the irrigation of ce or occasionally of sugar, the land is almost invariably divided by ɔme method of gridiron work of furrows and ditches as will most onveniently cover the area to be irrigated, excepting in cases where he water is sprinkled by hand.

In an interesting paper discussed by Mr. Baldwin Latham before the nstitution of Civil Engineers,[a] he gave a novel description of the cir-ulation of water in soil as shown by some experiments which he had nade with the object of discovering the precise difference between the ıpplication of water in rice irrigation where it stands stagnant on the and and other irrigations where a constant current is kept moving. The result of these experiments showed that where a surface velocity vas created it would promote a circulation of water throughout the soil, a matter of considerable importance, as by that circulation manu-ɜial matters were equally distributed while other material was removed which was not required by the plant, and which if allowed to stagnate would produce those ill effects shown when cultivating rice. The experi-ments were conducted in a water-tight glass tank which was filled with fine silver sand into which was poured a solution of perchloride of iron. Over this a solution of nutgalls was allowed to pass slowly and the course of the circulation could be readily followed, as the point of

[a] Discussion of irrigation in northern India: Proceedings Institution of Civil Engineers, London, vol. 35, p. 172.

contact of the two mixtures produced tannate of iron or ink which portrayed a perfect diagram of every stage of the experiment. The result of the experiment showed, among other things, that where there was an inclination of the surface resulting in the production of natural currents over it, a circulation through the soil took place.

Another tank experiment was made giving the conditions of a rice irrigated field. The same materials were used, but the tank was kept level, and it was found that after six months' contact no discoloration of the sand had taken place to a greater depth than one-fourth of an inch, showing there had been no displacement of the water occupying interstitial spaces in the sand. Mr. Latham said that the circulation of the water through the soil, on all land having an inclination, had a marked beneficial influence on irrigation, as conclusively shown from the practice adopted for generations in the irrigated districts of Piedmont and Lombardy, Italy, where, as the headwaters are left, it is customary to increase the natural slope of the irrigated beds in order to create a greater velocity, and hence a greater circulation through the soil.

CHAPTER VIII.

STORAGE WORKS.

CLASSES OF WORKS.

'he employment of storage works in connection with irrigation jects is resorted to in order that an assured constant supply of er of a given amount may be furnished by their aid to any area irrigable lands during each and every season, regardless of the ount of rainfall occurring and of the question whether it be an ormally wet year or one of unusual drought. Where great perial streams flow through land to be irrigated there is never any essity for the addition of storage works as a protection against failure of the water supply, but where valuable lands are to be gated and the source of water supply is from intermittent or very all streams, it becomes necessary to supplement the perennial flow urring in these during the irrigating season by the storage of the d or waste waters lost during the remainder of the year. This l is attained by damming the stream in some place where it will d a broad valley and create a large artificial lake or reservoir, or diverting its waters to some depression or other reservoir site ere it can be conveniently stored.

Two classes of storage works are generally referred to by Indian gineers—namely, reservoirs and tanks. There seems not to be any rules for distinguishing the two, as works sometimes called tanks e frequently larger than the largest reservoirs. Merely for purses of convenience in discussing the subject, the author will adopt e common practice of considering reservoirs as bodies of water tained by a dam constructed wholly of masonry, while tanks are rage works the dams of which are constructed wholly or in part of rth. Reservoirs are usually deeper than tanks and are constructed running and flood streams, while tanks are generally shallower d are constructed on minor and unimportant streams, the flood scharges of which are so small that all the water can be either ored or safely wasted, thus not endangering the integrity of the am, or they are constructed in depressions on the plains or interuves adjacent to the streams from which water is diverted to them.

In general, works for storage purposes may be filled from canals iverted from some large stream or filled directly from the discharge f the catchment basin of the stream upon which they are located.

The location of, necessity for, and probable return from the construction of a storage work is always a subject which receives much careful thought, both from the engineering and financial departments of the Indian government, before the work is finally sanctioned and undertaken. Many different considerations have first to be discussed and weighed in deciding the location. The work should be placed at a sufficient elevation above the lands which it is intended to irrigate to allow the delivery of the water to them by natural flow. The storage work may be so situated that it is immediately adjacent to the lands, in which case a very short canal will serve them, or it may be at some distance from the lands to be irrigated, thus requiring a long line of canal. Again, the storage water may be turned back into natural drainage channel when required, and be permitted to flow

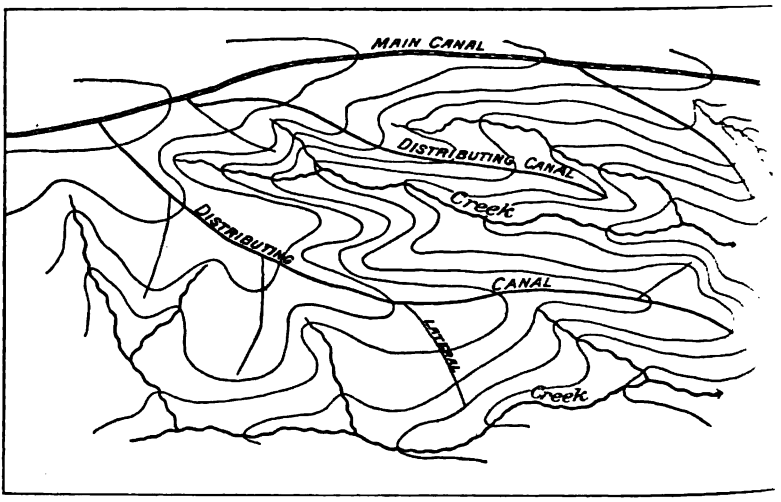


FIG. 37.—Drainage map, showing arrangement of distributaries.

down to the neighborhood of the lands where it will be again diverted for irrigation purposes. The second case mentioned may be costly if the canal line be long, but the last is invariably the most expensive method, as it is wasteful of water, the loss of which is greater by absorption and evaporation than in a well-constructed canal, while there is incurred the additional expense of a diversion weir at the point where the stream is turned from the natural channel into distributing canals.

Having decided upon the location of the lands to be irrigated and knowing their area, the first consideration attacked by the engineer is the location of the storage site. This may be discovered after much time has been spent in making trial surveys and investigations, in order that it shall be desirable for its purpose it must be of such character that the cost of its construction will not be prohibitory considering the source of the water supply from which to fill the

work a thorough hydrographic survey of the catchment basin ve the reservoir is necessary, in order to discover the maximum minimum precipitation, the percentage and rate of run-off, and total quantity of water available for storage. Stream gagings maintained for a few years, and all possible effort made to dis- er the volumes of maximum floods as well as the total quantities vater discharged. To these ends a good topographic survey is executed, as from the maps thus constructed the relation can be studied between the irrigable land and the reservoir site and latter and its catchment area. These maps enable the engineer ıeasure the areas of the catchment basins and to calculate the dis- rges from these areas, provided the rate of run-off is known. The ian government has already constructed over most of its territory ood topographic map, on a scale of 1 mile to 1 inch, upon which topography and outlines of hills and valleys are indicated in hach- s, and numerous elevations are marked at prominent towns, passes, l mountain peaks. In addition to this, much of the more densely abited portion of the peninsula has already been surveyed and pped for revenue purposes, on the large scale of 4 inches to 1 mile. th the aid of the latter map it is possible to determine with much uracy the various fields and plats of land which are to be served the irrigation scheme and their general relation to the distributory ınnels, while the smaller scale maps enable the engineer to solve the general problems in connection with the catchment basins, eams, general location of storage site, and the general course which distributing canal or other medium must take in order to conduct water to the lands to be irrigated. Such maps as these are of the atest possible service in the designing of any scientific and general ıeme for the development of the irrigation resources of a country, d enable the engineer, like the general in command of an army, to ıster all his forces, look over and conceive at a glance the problem be attacked, and decide upon the best mode for the utilization of the resources at his command for the general good of the whole ea to be served.

After the preliminary problems have been solved the more detailed nsiderations are investigated. In locating the dam site it is neces- ry, first, to have above it the largest possible basin or valley, with low or flat a slope as is obtainable, in order that a maximum storage pacity may be had. The site should be so chosen that it shall quire the shortest possible dam to close it and yet afford a suffi- ently wide waste weir to discharge the maximum flood without injury the dam. Finally, it must be so located that the geologic forma- on shall be favorable. The dam must not be founded on a porous ormation, and, if of earth, the material of the abutments and founda- on must be of suitable quality to afford an impervious connection. f a masonry dam, it should be founded on solid rock. A study of

the general geology of the neighborhood in order to ascertain wh the valley which is to be used as a storage site is an anticlinal or clinal valley, or one produced by simple erosion, is of great impor as indicating the dip of the underlying it and the pos value of the same as a noncond ing medium for the water stor the valley. Material for the struction of whatever class is decided upon must be co ient to the site in order to red to a minimum the cost of tra portation and construction.

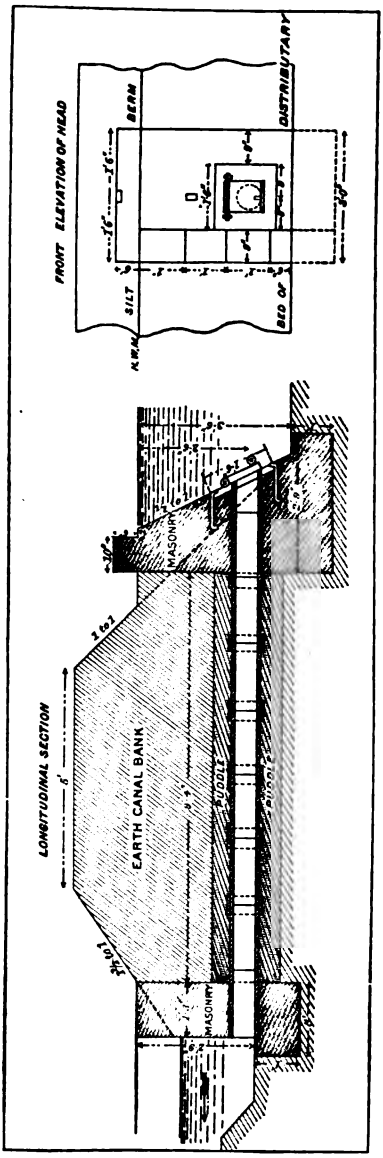


FIG. 88.—Standard masonry outlet for distributaries, Punjab.

In studying a catchment the Indian engineer has re to a few simple formulas to as in determining the flood disch from the area under con tion, and as a check on the re obtained from local observa The following are two of the mulas most used:

Ryves's formula, $D=C\sqrt[3]{M}$

Dickens's formula, $D=C\sqrt[3]{M}$

in which M represents the of the catchment basin in sq miles, C is a coefficient depe for its value upon rainfall slope of ground forming the ba etc., and D is the resulting charge, usually shown in ter cubic feet per second. It be borne in mind, however no such formula can be s applicable with the same cient to areas of varying even in the same part of the try and under the influence same intensity of rainfall. the other circumstances, su the slope of the ground, char of the soil, etc., be approximately similar. The chief difficulty be found in the selection of a suitable coefficient, and a few of for different districts in India, which correspond in general char istics to the arid region of the United States, are here given.

regions where maximum recorded rainfalls of from 3 to 6 inches
venty-four hours have occurred, the coefficients for Dickens's
ula, which have been settled upon, are about as follows:
ıximum rainfall 3.5 to 4 inches, in flat country, C = 200; mixed
ıtry, C = 250; hilly country, C = 300; and for a maximum rainfall
inches C varies between 300 to 350, according to the nature of the
ıtry. The corresponding number of inches of drainage for a stand-
area of 5 square miles from these figures would vary, for the first
p between 5 to 7.5 inches, and for the second group between 7.5
5 inches. For Ryves's formula the coefficient varies between 400
500, and for very hilly areas, where the maximum rainfall is high,
ay reach as high as 650. The flood discharges are invariably
ortionately less for large basins than for smaller ones.
very interesting paper on this subject of maximum flood discharge
ı catchment areas was read by Mr. James Craig before the Insti-
on of Civil Engineers in 1884.[a] The details of the argument entered
in this paper are too elaborate to be presented here. In general
are an amplification and discussion of results obtained from
iously shaped catchment basins, showing new methods of deter-
ing the loss of discharge other than those obtained by the two
nulas given above.
ı order to show the character of the detail connected with the
ious investigations and problems to be solved when the value of or
essity for the construction of the storage work is under considera-
ı in India, attention will be called to a few of the questions which
Indian engineer is directed by his superiors to investigate. These
nts and others not included herein are laid down by General Mul-
s, chief engineer of irrigation for the Madras government in India,
the guidance of engineers in that presidency.[b] The general cir-
nstances of investigation are whether the valley or drainage area
der consideration is partially occupied by tanks or is unoccupied.
ere will be some prima facie evidence available about particular
es or what the inhabitants suppose would be suitable sites. It may
desired to supply water to a definite area of new land to be irri-
ted or to land that had a previous supply which has been stopped
the silting up or destruction of existing tanks.
In the preliminary information the average rainfall of the country
d its character are obtained from any records which may be in exist-
ce. The irrigation duty of the drainage area in square miles or
me other unit is ascertained, as well as the quantity of water deriv-
le from this unit of catchment area and the average rates of assess-
ent for irrigable lands. The preliminary investigation includes, as
fore stated, a study of the atlas sheets of the survey of India and
the revenue survey maps, an examination in detail of the country

[a] Maximum flood discharge from catchment areas: Proceedings Institution Civil Engineers, ndon, vol. 80, pp. 201-220.
[b] Irrigation Manual, E. F. Spon, London, 1890, p. 55.

in order to ascertain the most suitable reservoir sites, and an exa[illegible] tion of the drainage lines thence downward. To be considered, [illegible] usually must be in a valley which has a moderate longtudina[illegible] with moderate transverse slopes on either side of the axis of th[illegible] ley, must admit of a moderate length of dam with suitable abutm[illegible] at either end, a probable moderate depth of water and corresp[illegible] ing height of dam, suitable material for the formation of the d[illegible] and possess facilities for the disposal of surplus, preferably by w[illegible] ing over detached saddles through rock soil or subsoil. Land [illegible] the site must also be available for irrigation, and there should [illegible] absence of much or valuable cultivation and of villages withi[illegible] probable area of the water spread. Whether water storage m[illegible] obtained on financially advantageous terms will depend larg[illegible] the difference between the values of the land when irrigated [illegible] when not irrigated. In order to ascertain this difference in v[illegible] it is necessary in India, as in America, to know what area a [illegible] quantity of water can irrigate, what that area will pay for the wa[illegible] and what the storage and distribution of the water will cost.

In various discussions of storage capacity and water duty, herea[illegible] to be entered into, the author will for convenience use the storag[illegible] employed by the United States Geological Survey, 1 acre-foot. T[illegible] is 43,560 cubic feet, or the quantity of water which will cover [illegible] in area to a depth of 1 foot. In dealing with large quantities of w[illegible] such as those stored in great reservoirs, it is inconvenient and tro[illegible] some to speak of capacities in millions or billions of cubic fe[illegible] the much smaller figures which will be dealt with by using the [illegible] foot as the unit of measure make the subject-matter more intel[illegible] Likewise the area of land irrigable from a given amount of st[illegible] water can be more conveniently considered; that is, the duty of storage water can be spoken of in more convenient terms if we [illegible] to the duty performed per acre-foot. Thus, in portions of Co[illegible] the duty of an acre-foot, providing the distance which the water [illegible] to be carried to the land is not so great as to cause excessive [illegible] absorption, may be stated as being 1¼ acre-feet per acre.

As an instance of the cost of storing water, the investigations [illegible] Bombay engineers show that in favorable cases where water ha[illegible] stored in reservoirs of the first class 56,700 cubic feet, or about 1[illegible] feet, of water has been stored at an average cost of $1. The co[illegible] the water, however, when served to the field will be considerably [illegible] this, as the loss due to evaporation and absorption in the re[illegible] during storage period and the loss due to the same causes in c[illegible] ing the water through the canals to the fields to be irrigated m[illegible] included in the estimates. In this same locality in Bombay, [illegible] considering these losses, it appears that about 38,000 cubic fe[illegible] water can be stored at an average cost of $1.

RESERVOIRS.

efore entering into a description of the details of construction of ious notable reservoirs employed in India for the storage of water purposes of irrigation, it will be well first to look at some of the ncial results and general statistics relating to these works. In the owing table, compiled from the irrigation revenue report for Bom- for the year 1900–1901, are given the principal data in connection li the chief reservoirs of that presidency, namely, Bhatgur and te Fife:

Reservoir works, Bombay.

	Bhatgur dam and Nira canals.	Lake Fife and Mutha canals.
a of catchment ..... square miles	128	196
erage annual rainfall ..... inches	145	32.4
ailable contents ..... acre-feet	126,500	75,500
rface area ..... acres	3,584	3,630
ea commanded ..... do	274,447	94,087
ea irrigated ..... do	113,280	16,800
ight:		
Above foundation ..... feet	127	97.8
Above river bed ..... do	108	.....
ain canal ..... miles	100	88
stributaries ..... do	139	70
tal cost, including canals	$3,138,000	$4,448,000
ea irrigated:		
Summer crop ..... acres	21,602	7,575
Autumn crop ..... do	30,126	629
Total	51,728	8,204
ercentage double cropped	.....	8.7
verage discharge utilized ..... second-feet	103	.....
rea irrigated, per second-foot of discharge utilized, acres	139	64

The following table gives some of the figures connected with the ater supply of the irrigable land served by these two projects for the ear 1889:

	Nira canals.	Mutha canals.
ainfall on irrigable lands ..... inches	15.1	31.5
uty, autumn (four months) ..... acres	118	60.5
ost of water measurement per acre ..... cents	1.5	4
oss of evaporation in tank ..... feet	.....	4.5
Maintenance cost per acre irrigated ..... cents	31.0	.....

The working expenses on the Nira canal for the year 1900–190[illegible] [illegible] $17,000—$170 per mile on the main canal, or 33 cents per acre [illegible] gated and 89 cents per second-foot of discharge at canal head. T[illegible] returns realized being from plantations of trees on the canal [illegible] were $231, and the water rate charged during the same year was [illegible] cents per acre irrigated, or $56 per second-foot of discharge at [illegible] canal head. The total revenue was $60,000, and the net revenue [illegible] profit $27,400, or 1.45 per cent on the capital invested.

On the Mutha canal $960 were realized during the same year [illegible] the plantations maintained on the canal banks, while the water [illegible] per acre irrigated was $3.91, or $260 per second-foot of discharge [illegible] ing the canal head. As will be noticed, the water rate levied on [illegible] Mutha canals was very high relatively to that on the Nira, and [illegible] very high as compared with that charged on any other canal sys[illegible] in India. The cause of this was the great amount of sugar cane cu[illegible] vated along the canal, a crop requiring a great amount of wa[illegible] mature it.

In the following table are given some of the revenues derived [illegible] the cultivation of the various crops on the Nira and Mutha canals:

Crop.	Nira.		Mutha.	
	Acres.	Value.	Acres.	Va[illegible]
Wheat	3,190	$37,200	2,861	[illegible]
Sugar	143	7,100	4,277	[illegible]
Jowar	10,320	86,000	854	[illegible]
Bajri	3,038	30,200	1,336	[illegible]
Beans	783	5,200	440	[illegible]
Total	17,474	165,700	9,768	[illegible]

MUTHA PROJECT.

The Mutha canal scheme was first proposed by Colonel Fife, R. [illegible] in 1863, with a view to irrigate a large district in the neighborho[illegible] Poona and to furnish the water supply of that city and canton[illegible] The Mutha River, a tributary of the Bhima, rises in the We[illegible] Ghauts, 30 miles east of Poona. The rainfall on the Ghauts a[illegible] Poona is seldom less than 200 inches per annum and has never [illegible] known to fail. Plans and estimates for the project were finally [illegible] mitted in 1868, and in the latter part of that year the construc[illegible] the work was commenced.

The scheme comprises (fig. 39) a large storage reservoir, Lake F[illegible] on the Mutha River, 10 miles west of Poona, with two canals, on each bank of the river. It is the reserve storage supply from [illegible] reservoir which assures an unfailing flow of water in the canals [illegible]

rainfall is always more than sufficient to fill the reservoir. The nal on the right bank is 99½ miles long, and is designed to discharge second-feet at the head; however, its usual discharge is somewhat

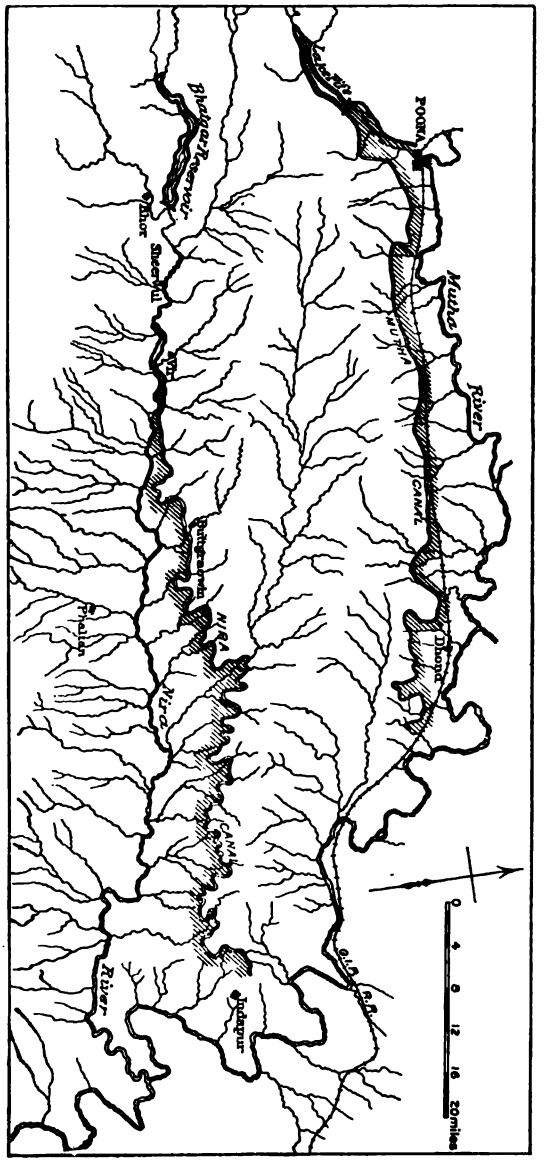


FIG. 80.—Plan of Mutha and Nira irrigation projects, Bombay.

ess, while if necessary it can be increased to as much as 535 second-eet. This canal passes through the town of Poona and commands 47,200 acres of land entirely within the dry zone of the Deccan,

where the rainfall seldom exceeds 20 inches. In this area the va-
tions in the rainfall and risks of drought are as great as the abs-
rainfall is small. The left-bank canal is but 14½ miles in length an
extends but a short distance beyond the town of Kirkee. It comma
an area of 4,300 acres and the discharge at the head is 38 second-f

The reservoir is formed by a masonry dam founded on solid r
This dam is constructed of uncoursed rubble masonry. Its to
length is 5,136 feet, of which 1,453 feet are used as wasteway. I
height above the river is 98 feet, while its maximum height above th
foundation level is 108 feet. The crest of the wasteway is 11 f
below the top of the dam, thus giving a maximum storage depth
87 feet. The dam backs the water up the valley a distance of 14 mi
The available contents of the reservoir are 75,500 acre-feet, and th
area of water surface exposed is 3,681 acres. In order to comma
sufficient elevation the beds of the canals are taken off at an elevati
of 59 feet above the river bed or bottom of the storage reserv
Thus the available depth of storage is but 29 feet. The river ab
the reservoir has a catchment area of 196 square miles, over wh
the rainfall is so great that only one-sixth of the whole discharge
the river is used. The design of the dam is unquestionably cr
As at first constructed it was 14 feet wide on top, with straight sl
on either side of 2 on 1 downstream and 20 on 1 upstream. The d
soon showed signs of weakness, and to strengthen it a great bank
earth 60 feet wide on top and 30 feet high was piled up against
lower face. The line of the dam is built in several tangents, w
changes of top width for each, according to the height of that po
of the dam, the points of juncture of the various tangents being ba
up by heavy buttresses of masonry. The cost of this structure w
about $1.75 per cubic yard, and its total cost was $630,000. W
under construction a temporary wall of masonry was erected at
distance below the main dam in the river bed, which was built up
a height of 50 feet. The object of this was to form a tempo
water cushion for the floods to fall on, so that they should not un
mine the main dam while the wasteways were being prepared.

The discharge of water from the reservoir into the right-bank ca
is regulated by ten sluices, each 2 feet square. These sluices a
closed by iron shutters and are operated by means of capstan
screw from the top of the dam. There are in addition eight cir
sluices, each 2 feet 6 inches in diameter, which are 1.33 feet lower
the canal sluices and are designed to supply water to turbines for
power. These latter discharge into the canal through the tur
chamber. Three sluices of a similar pattern to the canal sluices m
tioned are at the opposite end of the dam, for the supply of the
bank of the canal.

The right-bank canal has a bottom width of 23 feet and depth
feet, though its usual supply of water is about 5 feet. Its fall

·hes per mile to Poona, at which place there is a drop of 2.8 feet, ich is utilized by means of an undershot water wheel to drive pump- ; machinery for the supply of water to the town. The canal is car- d through Poona in a tunnel excavated in rock. At the fifty-first le the canal supplies Matoba tank, which is constructed as a relief rk and commands an area of 8,550 acres of irrigable land.

The Mutha project was designed and has been operated as a produc- e work, and was constructed from borrowed capital. As originally imated for, the total cost of the work, including land compensation, s to have been $2,664,000. The estimated revenue, including the ·enue from mill power and water supply to the city of Poona, was to ve been $207,000, or 7.78 per cent on the capital outlay. The total ıt of this work to the end of 1889 has been $2,082,000. The working penses were, in the year 1889, $2.08 per acre irrigated; the gross ·enue from irrigation was $37,000, and the total net revenue was ,000, including the revenue from all other sources, or 3½ per cent erest on the capital invested.

NIRA PROJECT.

Bhatgur reservoir is located in the Presidency of Bombay, about 40 les south of Poona, on the Yelwand River just above its junction th the Nira. The topography of the country thereabouts, in its ysical characteristics, its climatology, and the appearance of its vege- ion is very similar to that in northern Arizona in the neighborhood of ach Springs or Hackberry. It consists of high mesas or table-lands, ·minating in abrupt and nearly perpendicular rock slopes, and cut o by deep canyons, which open out rapidly onto broad bottom lands d valleys, leaving the mountain masses standing out boldly like the ins of great old fortresses.

The frequent failure and the general uncertainty of rainfall in the rtion of the Poona collectorate through which the upper Nira River ws caused Colonel Fife to turn his attention to devising some means r supplying this district with water for irrigation. Surveys made ıder his direction in 1863 showed that the system of small tanks ıich had been generally considered applicable to this region was, ıancially speaking, impracticable, as the slopes of the smaller val- ys are as high as from 30 to 50 feet per mile. The result of the ·tailed surveys then made was that these tanks at best afforded but limited area of irrigation, while a tolerable site for a tank was almost variably occupied by gardens irrigated from wells, thus rendering e land expensive.

Preliminary surveys for the Nira project were made in 1864, but ere soon discontinued. They showed that the canal must commence ear the town of Shirwal. In 1868 a committee was appointed to ıvestigate this scheme further, and the result was that it reported ıe district to be drought stricken, and said it would be advisable to

have surveys made at once for the construction of a reservoir on the Nira River, with a canal from the same. Surveys were resumed in the same year under Lieutenant Buckle, R. E. These were continued for some time, and were finally taken up by Mr. J. E. Whiting, C. E., under whose direction the project was finally constructed. Mr. Whiting's observations and surveys proceeded until 1871. They included the examination of several different sites and comprised detailed surveys not only of these sites, but of river-gaging and rainfall observations, and the cross sectioning of the valley along the canal line. The scheme as finally submitted, and as now constructed, consists of a reservoir on the Yelwand River and of a canal heading at Vir, on the Nira River, 19¼ miles below the reservoir site, the canal being [illegible] miles long and discharging 945 second-feet at the head (see fig. [illegible]).

The catchment basin above the dam site has an area of 128 square miles, and the fall of the river bed within the reservoir limits is [illegible] per mile. The water in the reservoir is backed up the valley a distance of 15 miles, and its total capacity is 126,500 acre-feet. The dam is 4,067 feet in length, and is composed of the best uncoursed rubble masonry laid in hydraulic cement. It is 127 feet in height above the foundation and its crest is 8 feet above high-water mark. Its extreme bottom is 74 feet wide, and the top is 12 feet, and is intended to be used as a roadway. The dam is designed on a modern cross section by a formula very similar to M. Bouvier's (fig. 40). When full the pressure on the toe is 5.8 tons per square foot, or 90.8 pounds per square inch, and when empty is 6.7 tons per square foot on the base of the dam. The water supply is such that this reservoir can be filled eight times in the year. Accordingly, it is evident that there is an immense volume of water to be wasted. The alignment of the dam curves in an irregular manner across the valley so as to follow the outcrop of rock on which it is founded. These foundations are excavated to a depth of 2 feet in the solid rock, which has required excavation sometimes as deep as 30 feet in order to reach homogeneous material. The greatest flood over the dam may be 50,000 second-feet, and this is passed off by 2 wasteways and 20 undersluices. The wasteways are constructed at either end of the dam, in the body of the dam itself, and are arched over so that the roadway is continuous above them. Their total length is 810 feet, and the flood may pass 8 feet in depth through them. The northern wasteway, on the left bank, consists of 45 arches of 10 feet span each which are closed by automatic falling gates. The wasteway at the south consists of 36 arches, with the same dimensions and construction as the others. Jutting out from the main dam on the downstream side in such a manner as to inclose these wasteways, are constructed wings of masonry which guide the discharged flood water into separate channels, which carry it into the rivers below the main dam.

Of the undersluices (Pl. XIX), 15 are constructed in the centre

BHATGUR DAM, NIRA SYSTEM, BOMBAY.

dam at its deepest point and are placed 17 feet apart, each being y 8 feet in dimensions, with their sills 60 feet below the high-water ı. With this enormous head these undersluices will discharge)00 second-feet, which is an average maximum flood, and they have cessfully withstood several years of flood without injury to the ıts of the ashlar masonry with which they are lined. Under full d the velocity through these sluices is 36 feet per second. Above ı row of 15 undersluices, and near the surface slope of the valley, two others of the same dimensions, one 2 feet above the main row l the other 50 feet above the main row. These sluices are con- ıcted, as are the main sluices, with a lining of the best ashlar

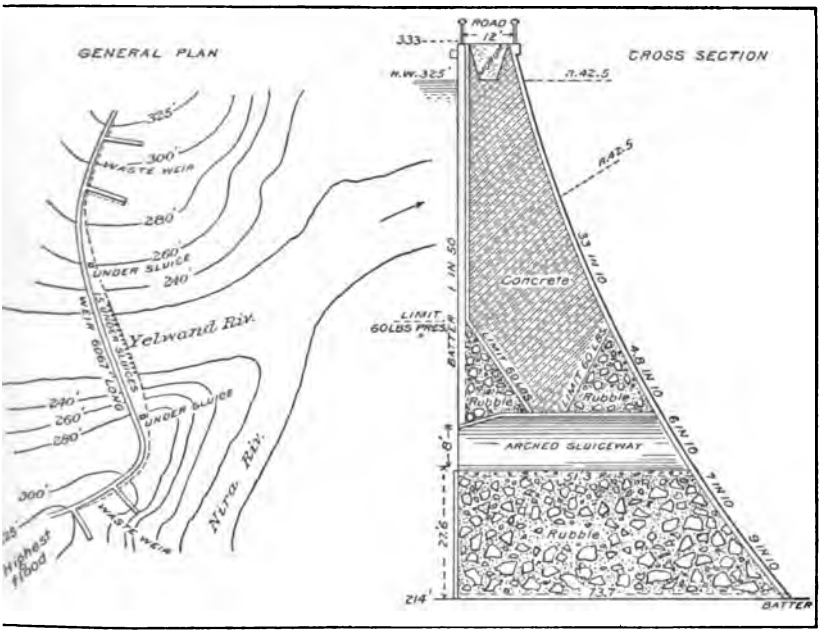


FIG. 40.—Plan and cross section of Bhatgur dam, Nira system, Bombay.

asonry, with pointed joints. They are closed by iron gates, which ide vertically. These gates weigh 2 tons each, and are operated by eel screws worked from above by a female capstan screw operated y hand levers. The gates are protected from injury by floating ɔjects by means of stout gratings of wood on the upstream entrance. here is 30 feet of idle space below the undersluices, and this is xpected to fill up with silt.

The object of these sluices is primarily to discharge the water of the eservoir, which then flows for nearly 20 miles down the Nira River to he diversion or pick-up weir at Vir, which turns it into the head of he Nira canal. Fewer sluices would have accomplished this end, but ıdditional ones were constructed with the object of keeping the reser-

voir above them free from sediment. This can be accomplished only by leaving the sluices open when much sediment is carried in suspension, and it is very doubtful if they would clean the reservoir of silt if it were once permitted to fill up.

Mr. A. Hill, superintending engineer, says of the scouring effect of these sluices:

Scouring sluices have little effect unless the area of the openings is great compared to the area of the floods. To remove silt already deposited they are useless as has been proven by the manner in which they have silted up at Lake Fife and at Vir and other places where their area is small compared with that of the area of the floods. At Bhatgur they are intended not to remove silt deposited already but to prevent its deposit by carrying it off while in suspension. If the dam is

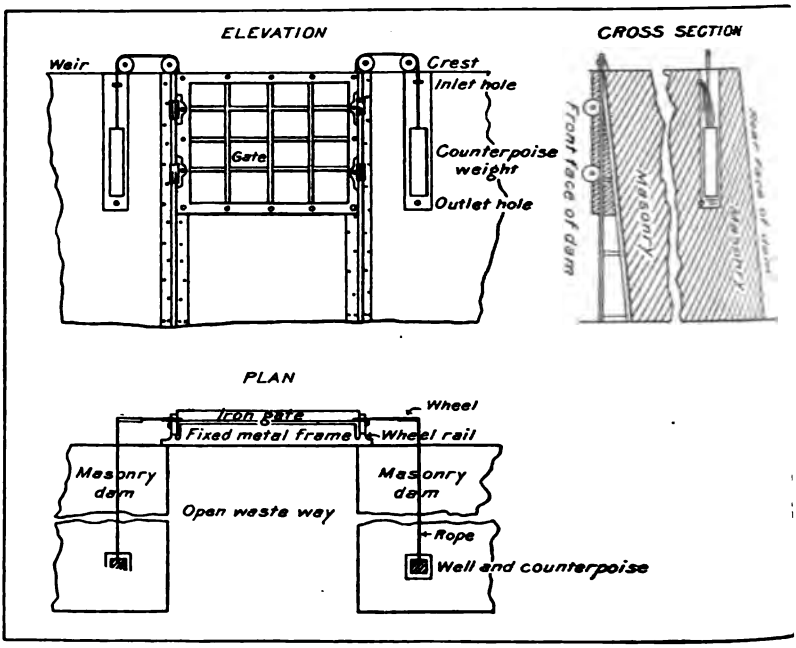


FIG. 41.—Diagram of Reinold's automatic weir gate.

high and the discharge of the undersluices will keep the flood level below the full supply level, then they will be efficient. If the dam is low and the sluices do not keep the flood level below full supply level, they will have little effect.

Experience on the Betwa reservoir and elsewhere bears out these conclusions, with the addition that their scouring or preventive effect is felt a very few feet to either side of the sluices, and silt will deposit close to their entrance. In other words, they do little more than keep an open channel above them.

The automatic sluice gates which are to be used on the waste-weir of this dam are peculiar, and are well worth describing. They are patented by Mr. E. K. Reinold, their inventor, and their object is that when the flood reaches its maximum height, 8 feet below the

ɔst of the dam, the gate shall be entirely open, and as the flood bsides the gate shall automatically rise until it is entirely closed, us adding to the reservoir capacity by the depth of the wasteweir. ıe gates are 8 by 10 feet, and they thus increase the depth of this ɜervoir by 8 feet. Where water is valuable such an expedient may of the greatest financial importance.

These gates have been in successful operation since about 1892, or r ten years, and have worked admirably. So much so, in fact, that ınilar gates are being placed on the Lake Fife dam, and have been

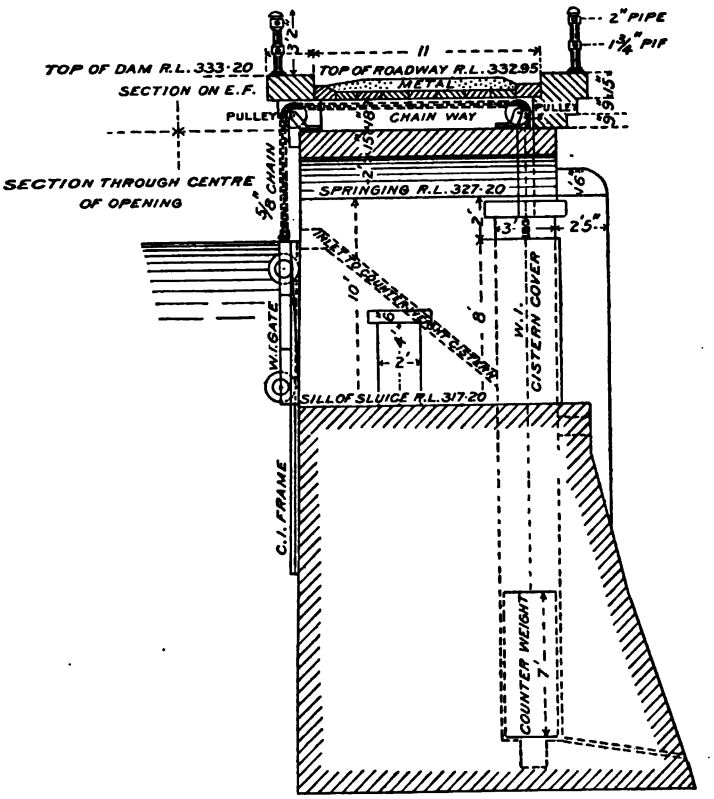


FIG. 42.—Section of automatic gates and crest, Bhatgur dam.

planned for others. The leakage at Bhatgur has been too slight to be taken in account.

The gate has two contact surfaces, one on the standard face against which it presses, and one on the face of the gate. These surfaces slide parallel to each other and are the surfaces of inclined planes. The gate rests on wheels running on rails and the axes of these wheels are parallel to the line of rails and at a slight angle to the contact planes, so that the latter do not touch until the gate is fully raised or closed, thus permitting by leakage a large amount of the flood water

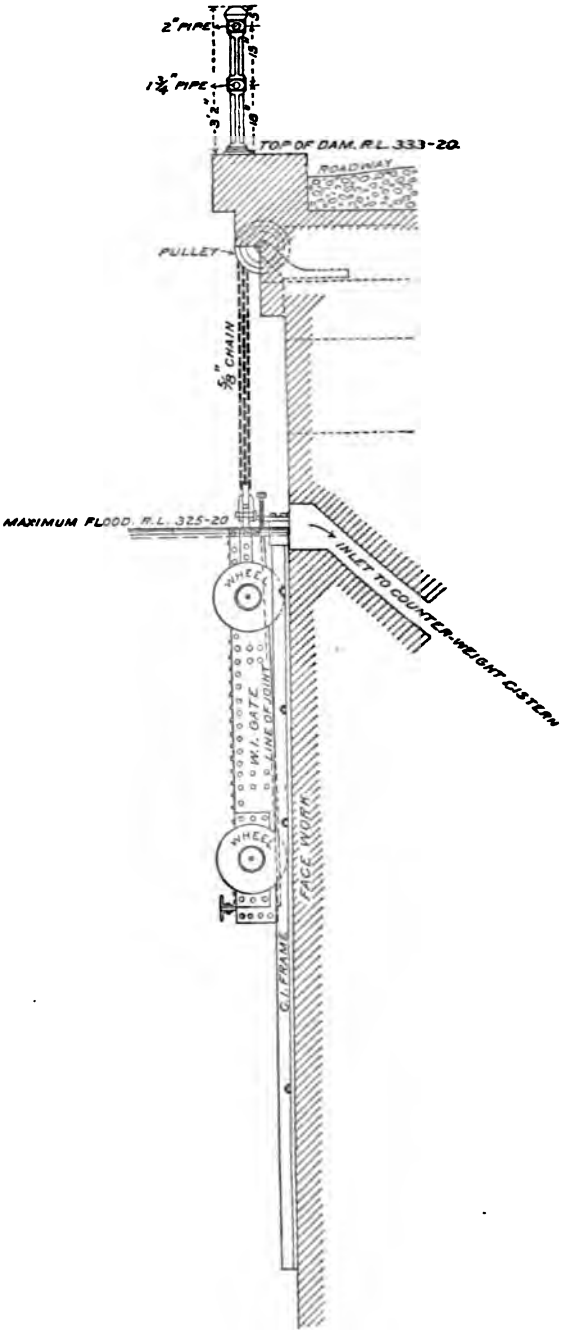


FIG. 43.—Detail of automatic gate.

A. VIR HEAD-WORKS, NIRA SYSTEM, BOMBAY.

B. KURRA AQUEDUCT, NIRA CANAL.

un out of them until the last moment. The accompanying illus-
ions (figs. 41–43) explain the operation of the gate. It is auto-
ically operated by means of counterpoises balanced in water cis-
ıs, the weight of which exceeds the weight of the gate by a little
e than the amount of the friction, and they act by displacing their
ıme in water in the cisterns in which they plunge, thus lessening
r weight by that of this volume of water. As the water flows over
top it flows simultaneously into the cast-iron boxes in which the
nterweights hang, through inlets placed on a level with the gate
This water entering the cisterns reduces the weight of the coun-
oises, and the gate then, being the heavier, sinks, opening the waste-

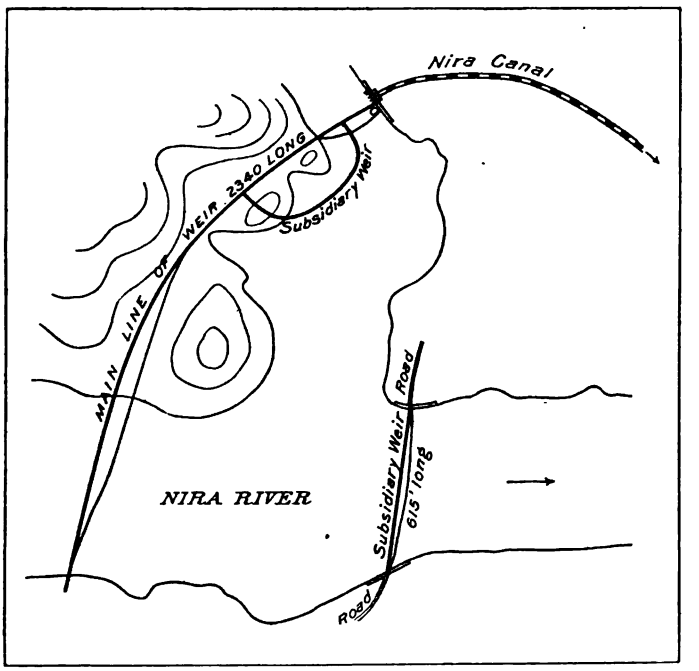


FIG. 44.—Plan of head-works, Nira canal, Vir.

When the water ceases to enter the boxes, owing to its having
n below the level of the inlets, it soon runs out from holes at the
ɔm and the counterweights then become heavier than the gate
lift the latter. Giving the proper weight to these counterpoises
e of the important details of the apparatus.
e Nira canal heads at Vir, 19¼ miles below the reservoir (Pl.
.1). The river bed between these two points being of a rocky
acter little or no loss from absorption takes place. The pick-up
version weir is constructed across the Nira River at its junction
the River Vir, and it crosses both of these streams and the point
nd between them (fig. 44). The total length of the weir is 2,340

feet, and its greatest height above the foundation is 43½ feet. The dam is constructed of uncoursed rubble masonry and is 9 feet wide on top (fig. 45). The rear slopes are 8 feet on 1 for 20 feet, and [illegible] for the remainder or lower part. The upstream face has a uniform batter of 20 on 1. At no place is the mean thickness less than [illegible] the weight of the dam. The main weir consists of two straight portions connected by a curved wall over which the water will not fall. This wall extends through the point of land connecting the two rivers and a channel 126 feet in width is excavated below it, connecting the rivers. The weir is founded on solid rock throughout, but to form a water cushion and break the force of the great flood which passes over it,

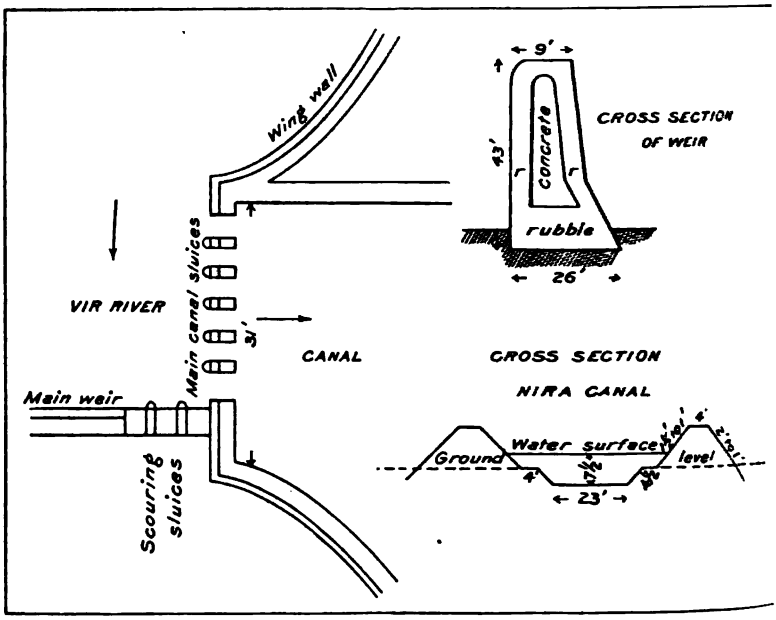
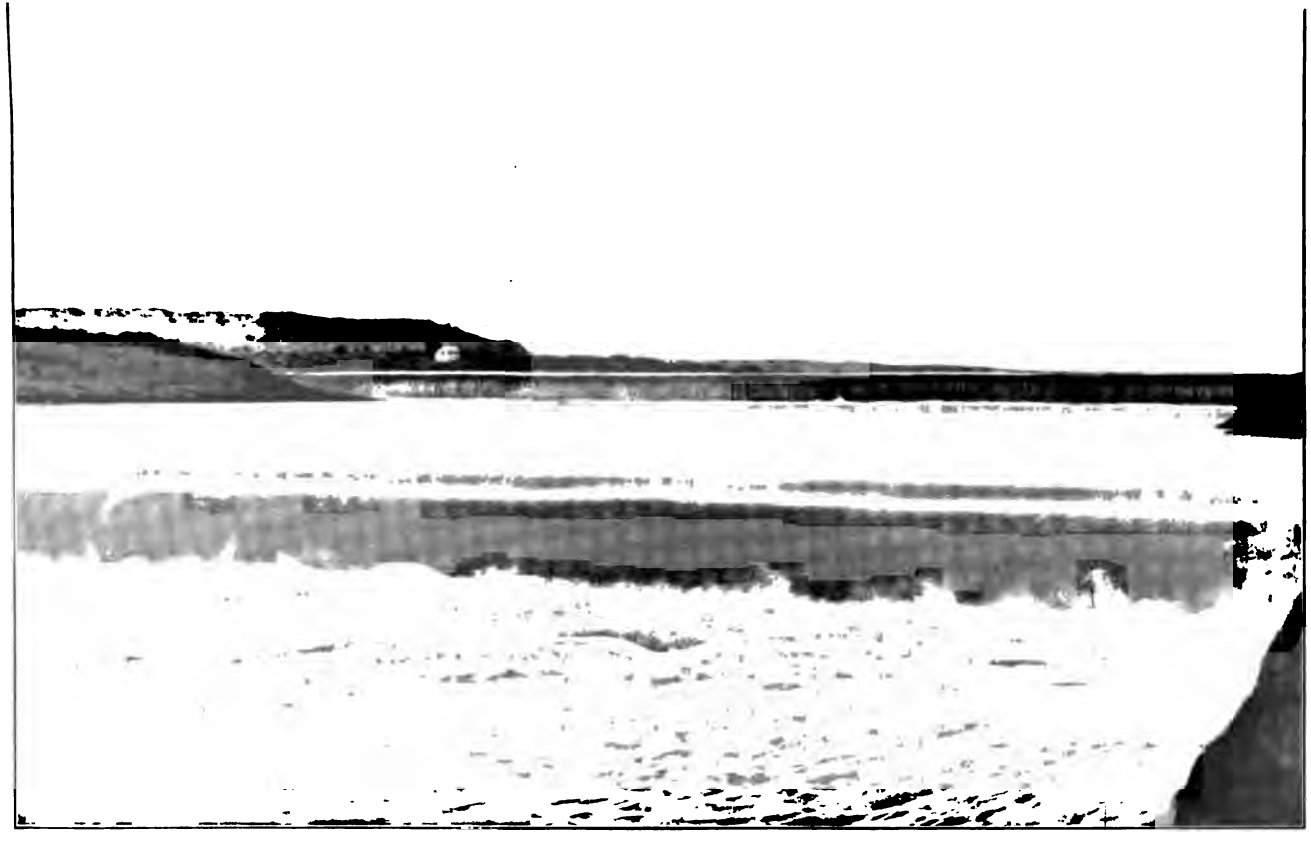


FIG. 45.—Plan of regulator head and cross-section of weir and canal banks. Nira canal.

it, a subsidiary weir, situated 2,800 feet below the main weir, is provided. The total length of this subsidiary weir is 615 feet, and [illegible] 24½ feet high, with its crest 20 feet lower than that of the main weir. It thus forms a permanent water cushion 20 feet deep below the main weir. Like the main weir, this subsidiary weir is constructed of the best uncoursed rubble masonry, and has a roadway on top. During a maximum flood, it is estimated that the cushion will be 32 feet deep when the overfall will be only 8 feet deep.

The catchment basin above this diversion weir is 700 square miles and the greatest flood estimated to pass over it is 158,000 seconds, corresponding to a run off of nearly half an inch per hour. The greatest flood which has occurred rose 8 feet over the crest of the main weir and 13 feet in depth over that of the subsidiary weir (Pl. XI.



MAIN CANAL AND SUBSIDIARY WEIRS, NIRA SYSTEM. VIR IN GREAT FLOOD.

› main weir backs the water up the Nira River a distance of 12 ›s to Shirwal and impounds about 1,400 acre-feet, or sufficient to rd a reserve supply for the canal for a few days. It is expected, ·ever, that this basin will silt up in the course of time. The canal ds from the left bank of the river at right angles to the River Vir . 44), and in a portion of the weir just below this head it has been nd necessary to construct a second subsidiary weir of trifling ensions which catches the direct flood from the Vir on a water hion (Pl. XX, *A*).

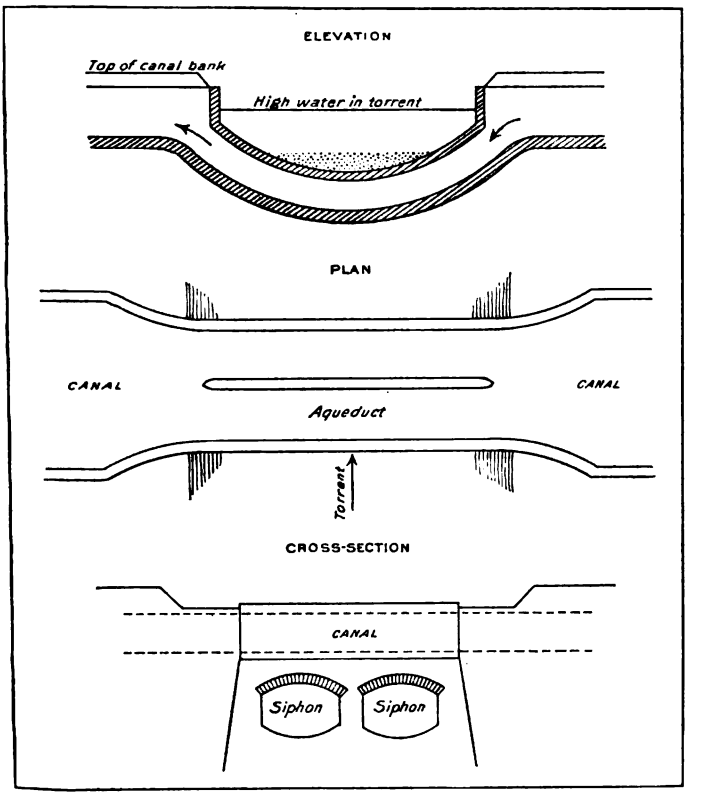


FIG. 46.—Nira canal; superpassage at siphon for Jewhar Torrent.

The canal after leaving the head-gates makes a long sweep through low ridge, curving until it is parallel to the river. In the cut rough this ridge, which is 400 feet in length, the average depth of cavation is 50 feet. The velocity in the canal averages 1.8 feet per cond. The regulating sluices (fig. 45) at the canal head are 7 in ımber, each 4 feet wide and have an available head of 9 inches. In e weir adjacent to the head regulators are a set of two scouring ıices which have not a sufficient area to remove silt which may ›posit, but which act as all other scouring sluices in keeping open a

clear channel past the head of the canal. At its head the bottom w[illegible] of the canal is 23 feet, the depth of water 7½ feet, and the discha[illegible] ordinarily 470 second-feet, while the fall is 6 inches per mile. As [illegible] present constructed the main canal is 103 miles long and contro[illegible] irrigable area of 300 square miles. There have been constructe[illegible] miles of distributaries commanding a portion of this area. The s[illegible] of the canal increases to 3 feet in a mile in rock cuts with a corresp[illegible]ing cross-sectional area. In earth where the canal cross sectio[illegible] small the greatest fall is 18 inches in a mile. The accompany[illegible] fig. 45 is a cross section of the canal showing the way in which [illegible] berms and banks are formed.

Numerous cross drainages are passed in the line of the canal [illegible] largest works being aqueducts over the Kurra River and the Wa[illegible] and a superpassage over the Jewhar Torrent. The Kurra aque[illegible] (Pl. XX, *B*) consists of 20 arches of 30 feet span each. The discha[illegible] of the river is estimated to touch the crowns of the arches at a ve[illegible] of 9 feet per second through them. The superpassage for the Je[illegible] Torrent is novel (fig. 46) and has an advantage over weirs, as the s[illegible]ing of the canal is avoided. This structure differs from an ordi[illegible] superpassage in being in solid rock, thus acting as a weir; also it [illegible] canal being carried under without any great drop or fall. The ca[illegible] clears the arching to avoid loss of velocity; in this it differs f[illegible] siphons. There is extra velocity and consequent narrowing of [illegible] waterway. Regarding the aqueducts, it may be observed that [illegible] the superpassages, the object has been to make them as narrow [illegible] possible without sacrificing too much fall, and the narrowed cha[illegible] is smoothly paved and grouted. It is estimated that the accelera[illegible] along this steep incline, together with the original velocity of appr[illegible] gives the requisite speed before the water enters the aqueduct. [illegible] inclination is given along the aqueduct sufficient to maintain [illegible] velocity and carry the water across, but directly the passage is cle[illegible] the canal is gradually widened and gets its regular fall per mile.

The total outlay on the Nira project to the end of the year 1[illegible] as follows:

Total outlay on Nira project to end of 1888.

Canals, distributaries, etc	$[illegible]
Bhatgur reservoir (uncompleted)	[illegible]
Twenty-three sluice gates and the subsidiary weir	[illegible]
Canal head-works at Vir	[illegible]
Nineteen aqueducts	[illegible]
Two siphon superpassages	[illegible]
Seventy-five small weirs	[illegible]
Hydrants, turbines, etc	[illegible]
Compensation for land	[illegible]
Total, including sundry others	1,4[illegible]

To the close of 1901 the expenses, exclusive of the Bhatgur [illegible]voir were: For main canals, $630,000; distributaries, $68,000; h[illegible]

'ks, $706,000; establishment, $342,000; tools and plant, $41,000; ıl, $1,787,000. The revenues to end of 1901 had been: Water rates, 2,000; plantations, $3,000; rent of buildings, $1,600; total, includ- miscellaneous, $367,000.

BETWA PROJECT.

'he first proposal for the construction of a canal from the Betwa 'er was made by Major-General Strachey in November, 1855. The 'stion was again considered after the mutiny in 1859, but nothing s done until 1867, when Lieutenant Home, R. E., was directed to ıduct the inquiry.

Lieutenant Home made examinations in 1867 and 1868, and sub- tted a preliminary report which showed that it was practicable to lize the waters of the Betwa River for irrigating a tract in Bundel- nd, in the Northwest Provinces, lying between the Rivers Jumna, huj, and Betwa, whereupon more complete investigations were lered. The examination was continued by Lieutenant Bagge and imate submitted. Further examinations were made later, in 1869, Mr. Anderson, under the general direction of Colonel Greathed, ief engineer, and the conclusions arrived at by him were that Pari- i was the best position for a diversion weir; that for four or five onths of the year 1,000 second-feet could be depended on even dur- g years of minimum rainfall, but that final further examination was lvisable. In November of the same year Lieutenant Bagge sub- itted a detailed project and estimate of the Betwa canal, including provision for water storage. The estimates were so high that the 'oject was shelved, especially as there was no prospect of the enter- rise realizing more than from 3½ to 4 per cent interest on the expend- ure. Finally, in November, 1873, the Government sanctioned the stimates, restricting the canal to wet-weather irrigation without pro- ision for navigation and without being supplemented by storage.

The works of the canal were designed and carried out under these eneral plans, but were afterwards modified so as to include a storage eservoir and irrigation throughout the year. Various sites were iscussed for the location of the storage works, that at Khoord being he most favorably considered for some time, but finally Paricha, a site ıreviously decided upon for the diversion weir, was accepted as the est location.

The area covered by the Betwa canal system is about 1,500 square niles. The surface formation of the bench land covered is very pecul- ar. The highlands border on the valleys of the Pahuj and Betwa 'ivers, while the lowlands occupy the central part, being drained by wo separate channels which unite as they approach the River Jumna. Owing to the irregularity of the rainfall and the excessive fertility of the soil on this area of land, it is difficult to make a canal project remunerative without supplementing its perennial discharge with

storage water, since during the ordinary season of the year, when river flows an abundant stream of water, the rainfall on the irrig area is sufficient for most of the needs of the agriculturist. The chosen for the diversion weir is an excellent one, the unusual w of the river bed at this point affording an ample wasteway for great floods which may be expected during certain periods. It necessary to design the storage dam as an overfall weir throughou entire length, as the maximum flood to be discharged amoun 750,000 second-feet. A rocky barrier or ledge runs across the b the river at this point and forms an excellent foundation for the w The river has a straight run between good stiff banks, and there plentiful supply of good building stone in the neighborhood.

For the first 20 miles the canal runs in a direct line, and is i excavation varying in depth from 5 to 40 feet. This portion of line is fortunately in earth and may be considered as purely diver line, being too deep for purposes of flow irrigation. The first of the canal are protected by a drainage channel parallel to it, w catches the discharge from the various small streams crossing right angles to the direction of the canal. Through this first por of its length the cross section of the canal is 20 feet at the b with a depth of 12 feet of water. The first 3 miles below the hea revetted both on the banks and the bed of the canal. This reve consists of a paving of loose stones carefully laid by hand. No s of any importance takes place in the canal, as the water is adm to it only during the season of moderate discharge in the river, as it is taken from the storage reservoir most of the sediment has b previously deposited. The growth of weeds, however, is rather ex sive, owing to the low slope of the canal, and the latter is period closed in order that the weeds may be cleared by hand.

One of the principal branches—the Hamirpur branch—is des with a bottom width of 15 feet for the first 30 miles and a de water at head of 6 feet, its slope being 1 in 3,000, which gives a v of 1¾ feet per second and a discharge of 340 second-feet. Fro point on, the branch diminishes gradually in dimensions and car capacity, the slope being continually altered so as to give an av velocity throughout of about 3 feet per second. Another main bra called the Kathund branch, has a bed of 30 feet and a depth of 6 and is designed to carry 500 second-feet of water.[a]

The local drainage met in the first few miles is disposed of by m of a parallel drainage canal having an inlet into the canal, and another channel near the canal head discharging into the Betwa R There are two drainage siphons, one in the seventeenth mile and on the Hamipur branch. The siphon on the main canal will dis 1,300 second-feet and is provided with five vents of 30 square which head the water up 1¼ feet and discharge it with a velocity

[a] The Betwa Canal Project in the Northwest Provinces, Records of the Government Calcutta, 1877.

; per second. The falls along the lines of the canal and the bridges of the usual pattern described elsewhere.

'he minimum discharge of the river may be taken as about 50 ɔnd-feet, while the maximum discharge may be as great as 750,000 ɔnd-feet. The average rainfall over the irrigated lands is 39 inches. ɔ gross area of land commanded is 522,800 acres and the culturable a is 348,586 acres, while the area irrigated at present is 180,000 es. The expenditure on the works, including all charges to the r 1893, was $1,435,000. These works include 19 miles of main al, 163 miles of branch canals, and 380 miles of distributaries. ɔ duty performed in 1887 during the fall crop was 67 acres per ond-foot of the discharge at the head, or 76 acres per second-foot

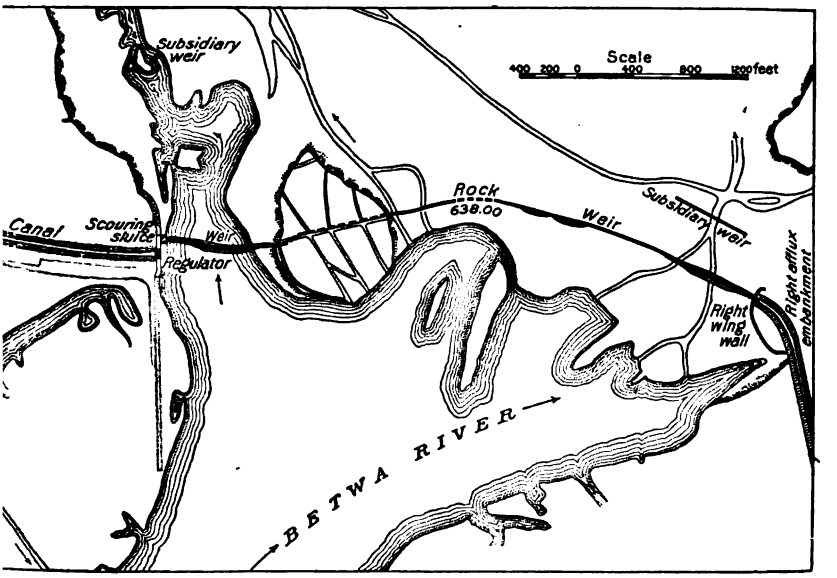


FIG. 47.—Betwa project; plan of dam and head-works.

the discharge utilized. The principal crops raised were wheat and ɪrley, with a small amount of pulses, indigo, and opium.

The weir alignment has been skillfully located so as to make the ost of the rocky barrier which crosses the river at the point where is constructed (fig. 47). The weir is placed on the ridge of this ef, which curves away from the left flank and is convex upstream, ɪ that the water will be thrown toward the middle of the channel. he height of the weir above the river bed varies between 0.4 of a ɔot and 60 feet, except on the left bank, where the rock was higher ıan the sill and had to be cut down. The total length between the ɛps on either protected bank is 3,296 feet and it is calculated to prouce an afflux in extreme flood of 6.5. The cross section of the weir ɜ at first proposed is a trapezoid with sides of equal slope, viz, 10

horizontal to 25½ vertical, the top width being 10½ feet. The engineer, Colonel Greathed, did not approve of this cross section decided that the downstream face of the weir should be nearly ver in order that a 6-inch film of water passing over the weir would clear of the toe, and in order to increase the stability of the w has been extended upstream somewhat. The upstream edge has rounded in order that driftwood may pass over without obstru and injury to the masonry, and a curve has been given to the ups face, instead of a batter, in order to facilitate the passage of w and drift.

The accompanying section of the weir (fig. 48) is for the high part. Fifteen feet has been adopted as a convenient and un width for the top, which is coped with ashlar 18 inches thick, the blocks being not less than 15 inches wide and weighing about 1 ton

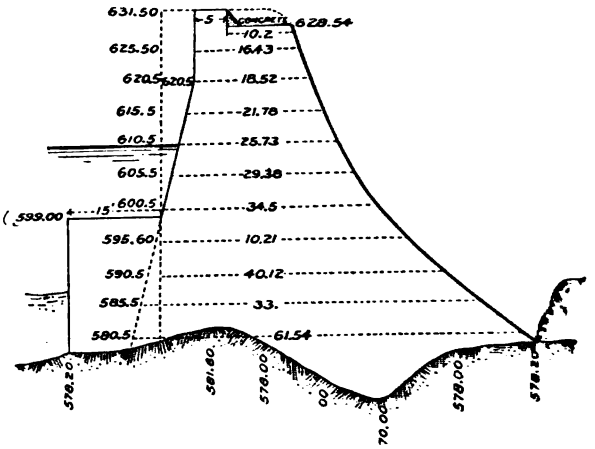


FIG. 48.—Cross section of Betwa weir.

The body of the weir is built of rubble masonry coursed on both the minimum dimensions of the stones being 9 inches long, wide, and 6 inches high, with a due proportion of bond stones ashlar is set in Portland cement and the rubble in native hydr lime cement. The body of the weir appears to be unnecessarily and heavy; especially is this true of the great block of masonry is placed at the toe. The cross section, however, was conside the engineers to be necessary, owing to the steepness of the the river and the magnitude of the floods which it discharges.

As shown by the accompanying plan of the river and of the crossing it (fig. 47), the latter is constructed in three different separated by a large island, on which it abuts in one place and rock which projects above the surface of the water in another The deepest portion of the channel is adjacent to the left bank the greatest height of the weir at this point, including foundati

newhat over 60 feet. At the toe of the weir on the downstream slope built out a great block of masonry from 15 to 16 feet in width, which ntended to receive a portion of the jar caused by the impact of the od water passing over the weir. Adjacent to the left bank a row of dersluices, four in number, are constructed in the weir itself, the ject of which is to give a scour past the canal head, thus keeping latter free of silt. The canal itself heads just above these underices, the regulator consisting of five openings, arranged with a double r of gates, one above the other, in such manner that either the upper

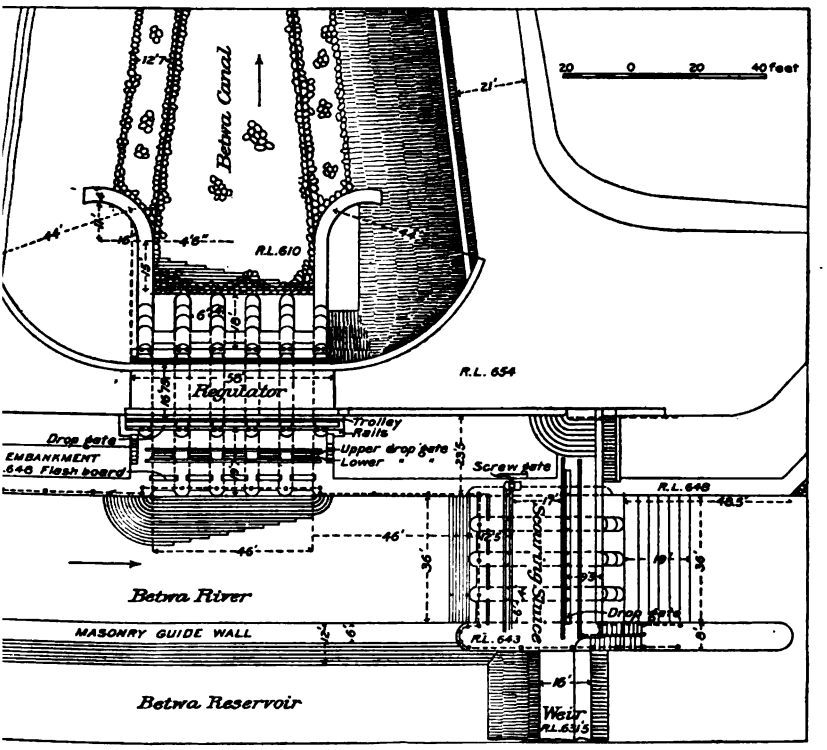


FIG. 49.—Betwa project, plan of regulator and scouring sluices.

lower series may be used at will according to the depth of water in e reservoir.

Below the portion of the weir across the main channel is conructed a subsidiary weir at a distance of perhaps 1,400 feet, the ject of which is to back the water up against the main weir, thus roducing a water cushion on which the floods shall fall. The xtreme height of this subsidiary weir is about 18 feet and the height overfall from the main weir to the water cushion formed by it is 1½ feet, though in time of flood this will be reduced to 8 feet. The p width of the subsidiary weir is 12 feet, and its walls are nearly

vertical on the downstream side with a slope of about 10 on 1 upstream. The main body of the weir between the island and the narrow right-bank channel is very low and the overfall is onto a solid rock bed. It was accordingly not necessary to construct a subsidiary weir below this portion of the weir, but across the right-bank channel where the height of the weir nearly approaches that at the extreme left bank, a secondary subsidiary weir has been constructed at a distance of about 200 feet below the main weir, and with the same object and same crest level as the subsidiary weir just described.

The available net storage depth of the reservoir is 21½ feet, and its capacity above the canal bed is 36,800 acre-feet, though it has been found that the lower 6 feet of depth is of little service, as the head above is not enough to force the water into the canal with sufficient freedom to make it practically available.

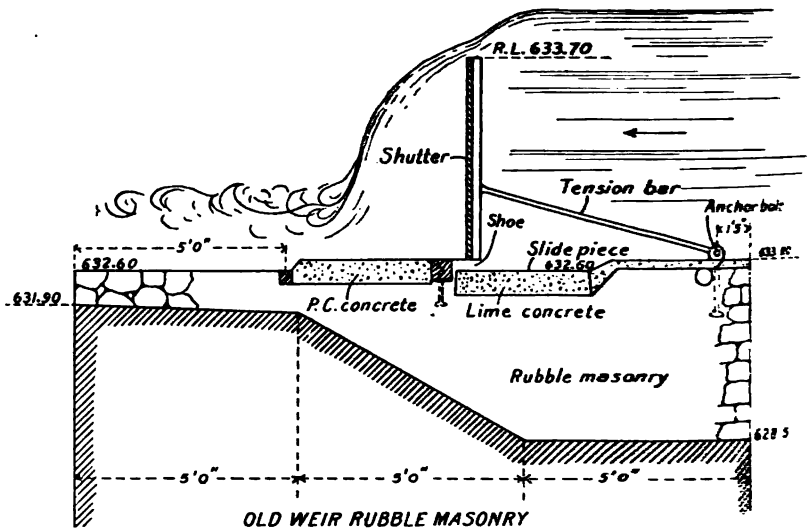


FIG. 50.—Automatic drop shutters, Betwa dam.

In 1897 the subject of increasing the storage capacity of this dam by adding automatic drop shutters on its crest was considered, and the plans for carrying out this work were finally approved and carried to completion in 1901. These works consist of two parts, namely, the building up of the weir crest by the addition of 1 foot in height of the best rubble masonry, and of shutters 6 feet high placed on top of these, thus making the total increase in height to which the water can be raised amount to 7 feet (fig. 50). By this means the gross increase in storage capacity of the reservoir with the shutters raised was 1,800 acre-feet, which is equivalent to an additional nine days' flood supply of the canal.

The shutters are illustrative of the latest Indian practice in the design of automatic drop gates. Moreover, they were subjected to the unusual test on completion, in 1902, in the form of an extra-

ary flood of 970,000 second-feet volume instead of the greatest maxi-
m anticipated, of 750,000 second-feet. This flood passed over the
st of the dam to a maximum height of 16.4 feet, when it had been
igned only to stand a previous known flood height of 6.5. For-
ately, the shutters worked successfully and rapidly, and neither
ir nor shutters sustained any material injury. These shutters are
h 6 feet high and 12 feet long, and as the length of the weir crest
3,600 feet there are 300 such shutters. They are made entirely of

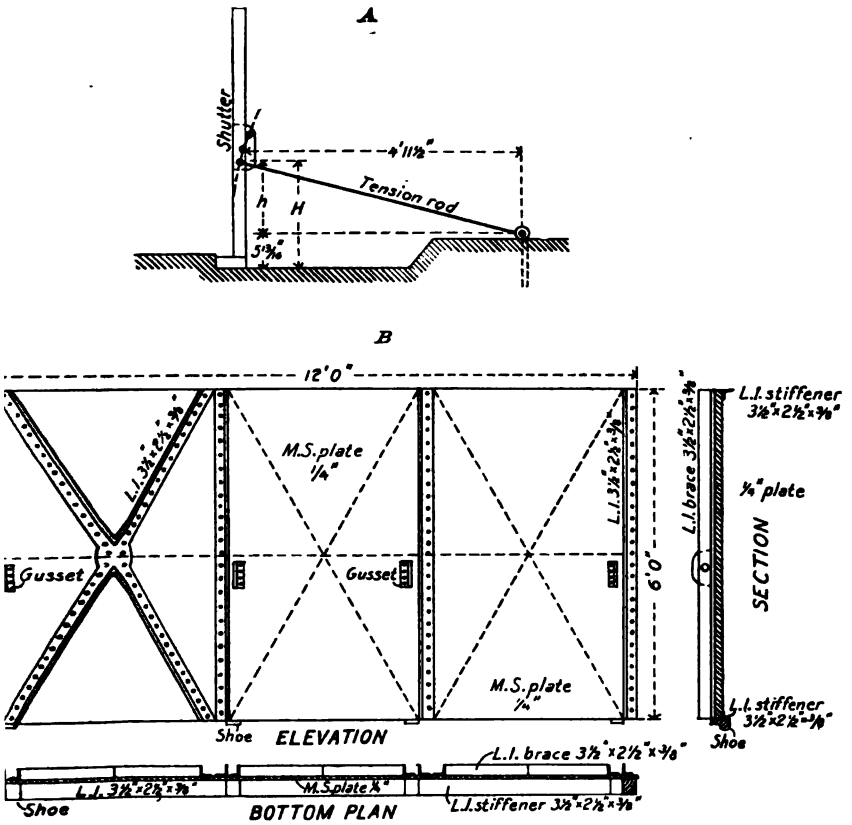


FIG. 51.—Shutter gates, Betwa dam.

teel, consisting of two one-fourth inch plates joined along their mid-
le and stiffened both longitudinally and laterally by angle iron 3½
y 2½ by ⅜ inches (fig. 51). To the flanges of the vertical stiffeners
re pivoted 1¾-inch tension bars. The other end is similarly attached
o anchor bolts built 2 feet into the masonry crest of the weir. There
re four such tension bars to each 12-foot gate. The point of attach-
nent of the tension bar and shutter is so designed that the gates fall
utomatically with a given depth of water passing over them, thus
ecuring safety in case of excessive floods. The bottom of each gate

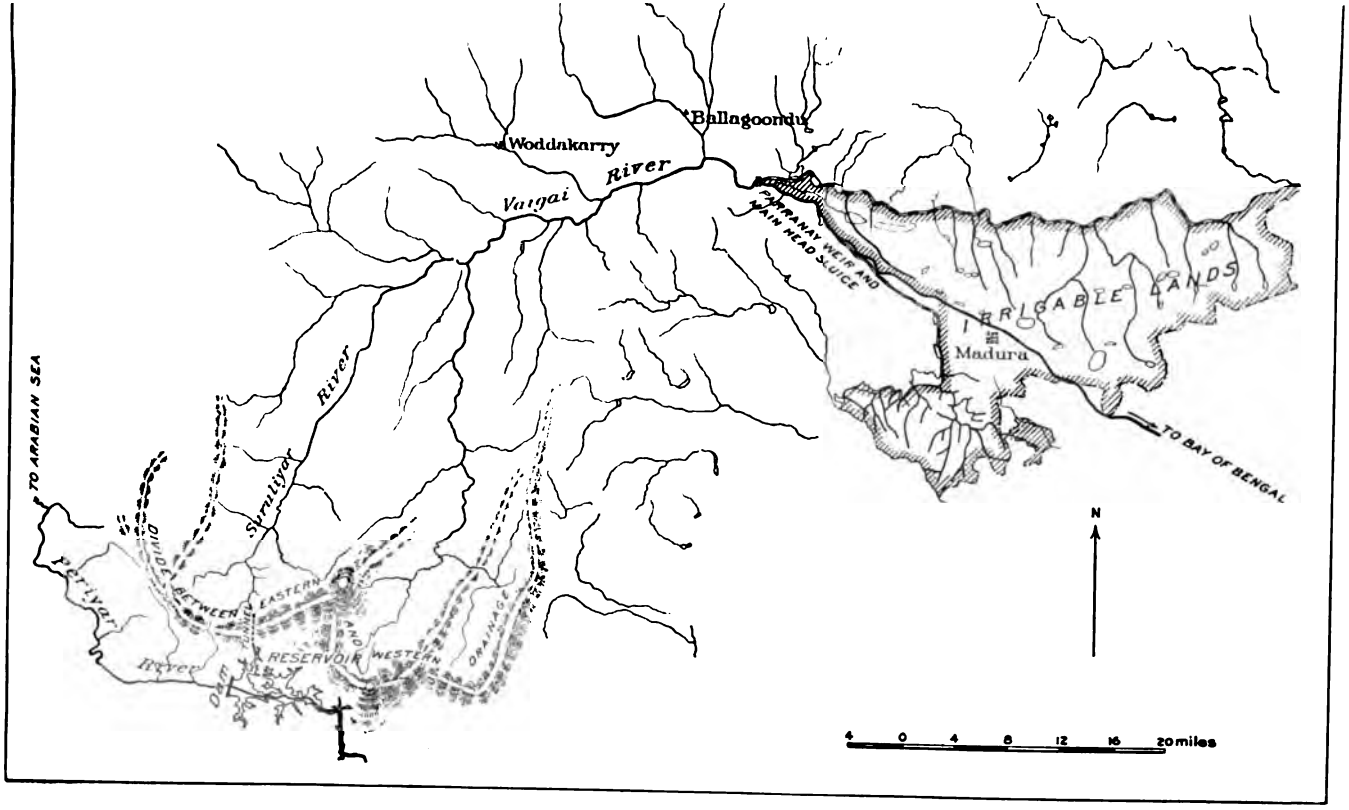
is supplied with four steel shoes which rest upon sliding plates bu into the weir crest, thus reducing the frictional resistance when the gates fall (fig. 51). Wooden boulks, 4 feet by 4 inches, are fixed the ends of the shutters, which have a space of 1 foot separating them which is calked when the gates are raised.

If the 300 shutters were to fall together, the shock would unit strain the weir and the flood volume submerge the river banks be Hence the attachment of the tension bars has been so arranged th each third gate falls under different depths of water. The first th fall with a depth over top of 2 feet, the next with 3 feet, and the la with 4 feet. Thus after the first third fall the released water red the flood depth, and the latter must increase considerably to top the second third, and so on. It was not anticipated that all the shutt would ever fall, yet this occurred in the flood above mentioned.

Careful calculations were necessary to determine the point attachment for each group of shutters, and as a fraction of an i would make a great difference in upsetting the gate careful exp ments were made with a model gate to determine the exact point attachment of the tension rods. So as to have uniformity of le of the latter, the pivot holes in the shutters were arranged in an arc circle at the required height from the bottom of the shoe (fig. 51.

Hole.	H.	Depth required to upset.
	Ft. in.	*Feet.*
1	2 0¼	2
2	2 1¼	3
3	2 2¼	4

The undersluices which are constructed in the main body of the weir opposite the canal head are placed at right angles with the of the canal regulator in order to give sufficient scour along the ca head to prevent the deposit of silt. The height of the face wa given a margin of 6 feet above the calculated afflux level. The un sluices consist of four vents, the bottoms of which are on a level the sill of the canal and are each 16½ by 16¾ feet in dimensions. T piers of the undersluices are 5 feet thick in order to support the g superincumbent weight of masonry. The abutments, piers, and cut-waters, etc., are of ashlar, the rest of the work being of ru masonry, the upstream face being pointed with Portland cem A peculiar curve is given to the upper face of the piers between sluice vents, forming a venar-contractor in such manner as to pass water with the least friction through the sluiceways. The sluices each closed by a series of two plain drop gates, the upstream gates being operated by a screw by means of hand levers from abo



PLAN OF PERIYAR PROJECT, MADRAS.

lower openings being closed by slash boards let into grooves in the 's.

he gates of the regulating sluices of the canal are of such cross-ional area as to admit 1,000 second-feet of water. The number of nings in the regulator is five, each 6 feet in width by 5 feet in ght, and, as before stated, are two decks in height, being closed by arate gates in such manner that either the upper or lower series of es may be opened at will, according to the depth and pressure of er in the reservoir. Below the main regulator gates, which are rated by screws by means of hand levers worked from above, are et of two safety drop gates, which are raised by means of a travel- winch. The accompanying drawings (fig. 49) illustrate some of details of construction of the regulating and flushing sluices. ese regulating gates, like those of the flushing sluices, are con-ucted of the best rubble masonry, finished with ashlar. The total t of the head gates and flushing sluices was $100,000, while the in weir, inclusive of the subsidiary weirs, cost only $160,000.

The left flank of the river is protected up and down stream by a ng wall, the former 140 feet long and the latter 75 feet long. The ole length of the wing walls is founded on rock, and, excepting the rapet, they are constructed chiefly of rubble masonry. In order to oid inundation by the afflux caused by the weir, embankments have en constructed on both sides of the river. The top width of these 20 feet and the center of each is hearted with a puddle wall 3 feet ick.

The Betwa project was sanctioned as a protective work. The total penditure on it up to the end of 1901 was $1,500,000, the total reve-ues from irrigation were $9,300, and the total working expenses ere $30,000; while the net revenue account showed a deficit over all ceipts, including those from irrigation, of $20,000. This work has een in operation but a few years and the revenue has been con-antly increasing in amount relative to the working expenses.

PERIYAR PROJECT.

The Periyar project for the irrigation of the Vaigai Valley, in Ma-ras Presidency, is probably the most interesting illustration of the ombined storage work and irrigation canal system to be found in ndia, especially as it was sanctioned as a protective work. The pro-ect (Pl. XXII) includes the construction of a dam to close the valley f the Periyar River to store 300,000 acre-feet of water, of which 50,000 acre-feet are above the sill of the outlet tunnel and are thus vailable for irrigation; the construction of a tunnel through the vatershed dividing the valley of the Periyar from that of the Vaigai River for the purpose of drawing off the water from the reservoir, with the necessary sluices and subsidiary works for controlling the passage of the supply of the Periyar down the valley of the tributary

called the Sooroolly, by which it reaches the Vaigai; and finally, the construction of the works necessary for the regulation and distribution of this supply for the command of 107,650 acres of land in the Vaigai Valley, of which 76,445 acres were irrigated in 1898–99. As the waters of the Periyar flow westward into the Arabian Sea, they are thus diverted across the peninsular divide, the Ghauts, to the eastern coast of India, where they enter the Bay of Bengal.

The area of country which is irrigated by this project was described by Major Ryves, R. E., in his early report on the project in 1867, as being about 1,200 square miles in extent, with a population of nearly half a million. Up to the present time irrigation has been practiced from native tanks, most of which, however, have become very shallow, and from which the waste of water by evaporation is at least 30 per cent. In very good years the water supply from the Vaigai itself is sufficient to irrigate 20,000 acres. Agricultural operations in this region are rarely rewarded by a good crop, although the land where water can be provided is of the most fertile character. During the famine of 1876 as much as $600,000 was expended in relief in this district.

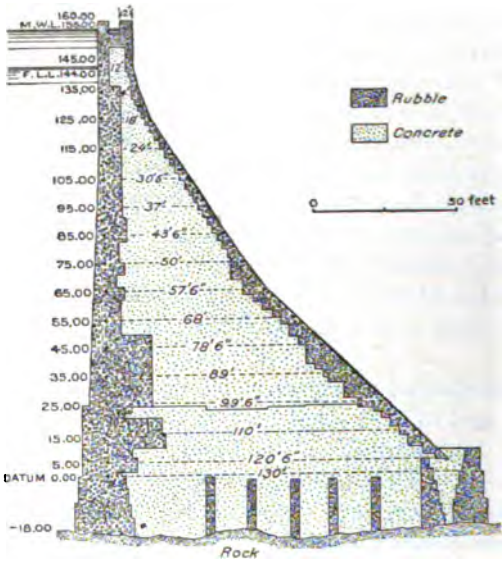


FIG. 52.—Cross section Periyar dam.

The idea of utilizing the water of the Periyar for the irrigation of the Vaigai is an old one. It was first reported in 1808 by Sir James Caldwell, who condemned the project as decidedly chimerical and unworthy of further regard. The subject was occasionally discussed from time to time, but it was not until 1867 that it was practically brought forward by Major Ryves. Major Ryves's proposals included an earth dam 162 feet high, with an escape crest 142 feet above the river bed and the water was to be diverted into the Vaigai Valley by a cutting having a maximum depth through the watershed of 52 feet. Other examinations were made, and finally a project was submitted by Mr. Smith in 1872, which included a dam 171 feet in height, to be constructed by the silting process and having an escape of 400 feet in length blasted out of the saddle at the right bank.

The final project, and that which has been adopted, was the only

PERIYAR DAM DURING CONSTRUCTION.

of further examinations made by Mr. Smith and Major Penny-
, though to the latter are due most of the later details, and under
s being conducted the construction of the works. It was in this
: that Major Pennycuick submitted the first proposals for the
tution of a masonry dam for one of earth. These final proposals
submitted in 1882, and included the construction of a dam (fig.
ocated at the same point as that chosen by Mr. Smith, 7 miles
Major Ryves's site, the height to be 155 feet above the bed of the
and the summit surmounted by a parapet 5 feet high and 4
. The dam proper is 12 feet thick at the top and 114¾ feet at the
t part. It is constructed throughout of concrete composed of 25
of hydraulic lime, 30 of sand, and 100 of broken stone. The
face is covered with a plaster composed of equal parts of lime

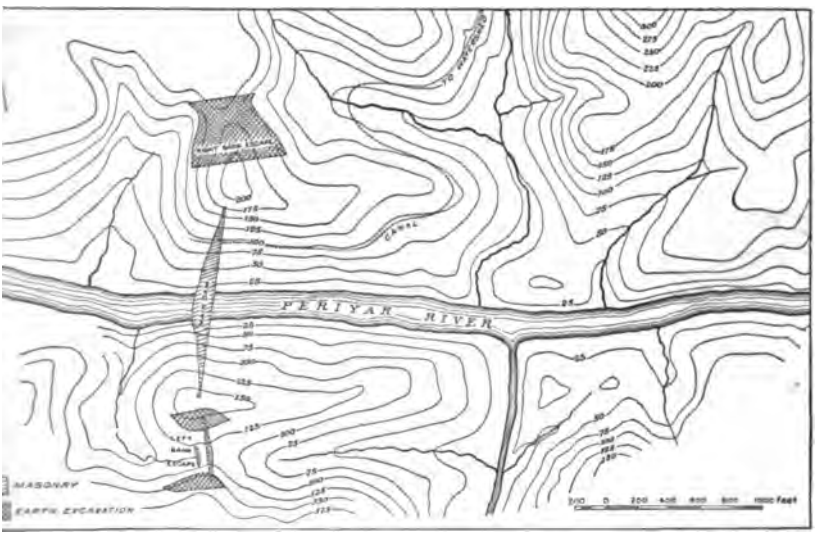


FIG. 53.—Periyar head-works, plan of dam and escape.

l sand. A temporary dam 30 feet in maximum height was con-
ucted above the main dam and a similar dam 10 feet high below the
in site, in order to enable the latter to be completely cleared and
foundation trenches blasted out before the main dam was begun.
For the formation of wasteways two saddles are utilized, one on
ch bank (fig. 53). The one on the right bank has solid rock at a
nimum level of 154 feet above the river bed, and will be cut down
a length of 420 feet to a level of 144 feet. On the left bank the
lid rock is at a level of 104 feet, and the saddle will be built across
th similar material to that of the main dam to the same level, 144
et. The wall thus formed has a length on its crest of 403 feet and
further length of 97 feet in excavation, making 500 feet in all. The
gregate length of the two wasteways is thus 920 feet. At a dis-
nce of 60 feet from the escape wall on the left bank is built a sub-

sidiary weir 10 feet in height, with its crest 30 feet below the upper wall, thus forming a water cushion. In the side of the valley tributary of the Periyar, just above the dam, a cutting was started at a height of 113 feet above the river bed running down toward the watershed, 21 feet wide at bottom, with a fall of 1 in 440. The depth of the cutting in rock is 50 feet at a distance of 5,400 feet from the starting point, where it is replaced by a tunnel with an area of 80 square feet and a fall of 1 in 75. At its lower end the tunnel will communicate with the bed of a small stream by a cutting similar to that at the upper end, 160 feet in length, the total length of the tunnel being 6,67[illegible] feet.

The rock in the river bed and on the watershed ridge is a hard syenite free from fissures and suitable both for a foundation for the dam and for material for its construction. Most modern dams of any magnitude have been built of uncoursed rubble masonry. Major Penny[illegible] argues that "concrete is nothing more than uncoursed rubble masonry reduced to its simplest form." As regards resistance to crushing or percolation the value of the two materials is identical; he further says, "unless it be considered as a point in favor of concrete that it must be solid, while rubble may, if the supervision be defective, contain void spaces not filled with mortar. The selection depends entirely upon their relative cost, the quantities of materials in both being practically identical." At the site of the Periyar works skilled labor is abnormally expensive and difficult to procure, while the facilities for the use of labor-saving machinery which can be largely used in the manufacture of concrete are unusually great. Accordingly, after full discussion, it was decided to adopt concrete as the material for the construction of the dam. Excellent sand is procurable from the bed of the river in numerous places above the dam.

The section of the escape dam (fig. 52) on the left bank is designed so that the lines of pressure shall be within the middle third when a depth of 12 feet of water is passing over its crest, and so that the water shall have a clear fall to the surface of the water cushion below. As before stated, at a distance of 60 feet from the upper escape dam is constructed another dam 10 feet in height, with its crest 30 feet below that of the former. The depth of water passing over this dam will be about one and one-half that passing over the upper one, so that the fall from surface to surface will vary from 24 to 30 feet, and the depth of water cushion from 10 to 28 feet. The length of the right bank wasteway is fixed by the quantity of stone required for the dam. The quantity is 3,600,000 cubic feet, of which 1,400,000 are brought from the watershed cuttings, the cost of conveyance being less than that of quarrying at the dam site. The balance after the material has been supplied from other convenient sources is 1,600,000 cubic feet, to be obtained from the right bank waste way. It is contemplated that a great flood will raise the water to a level of 153.1 feet, while it would take several times this discharge to raise it to 155 feet. The maximum

d recorded occurred in 1869, and amounted to 65,500 second-feet; ng 131,200 acre-feet in twenty-four hours, and 7,100 acre-feet in hour.

'rom the mouth of the watershed tunnel the water of the Periyar ses by minor tributaries into the Sooroolly River (Pl. XXII), and is trolled by numerous regulating works along the course of the vari- tributaries of the Vaigai. These works consist chiefly of sluices simple form, their object being to pass the Periyar water around the 'erent weirs which have been constructed by the natives or Govern- nt in past times for the utilization of the water of the local drain- basin. None of these old works are provided with head-sluices. cordingly, the regulating sluiceways which are planned in connec- n with the Periyar project are designed to discharge the maximum ount of water which that project will furnish when the surface el of the stream above each weir is flush with the bed of the exist- channel.

In 1898 a Stoney patent free-roller gate was erected at the tunnel ad to replace the equilibrium shutters which were found unworkable. works in a cast-iron frame built in a masonry sluice chamber 15½ 15 feet in plan, the sill being 49½ feet below the top of the platform d 37 feet 3 inches below the full lake level. The gate is 12 feet inches high and 9 feet 6 inches wide and is supported on 20 irs of cast-iron rollers. It is of ¾-inch steel plate, suitably braced, worked by a screw-lifting gear and winch and is balanced by a unterweight to two-thirds its weight.

From the mouth of the tunnel to the junction of the Sooroolly with e Vaigai is about 46 miles, and for a further distance of 40 miles the ater is conveyed by the latter river, no works being required in con- ection with it until it reaches the Peranny, at which point the dis- ibutive works begin. The Peranny weir is a substantial structure lready existing and requiring but little improvement, the only altera- ons made being the closing of the undersluices, the leveling of the rest 5 feet above the floor of the latter, and some slight additions to he wing walls, apron, etc. Two main distributive canals have been lanned, passing close under the foothills surrounding the plains about Madura. These and their branches all terminate in natural drainage hannels. The quantity of water designed to be carried by the south- rn main canal is 1,500 second-feet at its head, where the depth is 6 'eet, and it is designed to irrigate 75,000 acres of land. The existing or northern main canal is to have a head-sluice of 20 vents, all of 5½ 'eet span. The steepness of the Vaigai Valley necessitates the con- struction of numerous drops or falls in both the main and branch chan- nels. For the passage of cross drainage there are in all 26 inlets and 32 level escape outlets on the main canal, besides 2 aqueducts and 6 culverts, 3 inverted siphons, and other works. The head and regulat- ing works for the main canal and a secondary channel called the

Vedacunay channel, are only 1,460 feet apart. It is necessary, however, that both works be built, for the ground between the two is not favorable for an open channel. There 36 miles of main canals and 164 miles of distributaries.

The water supply is derived from the Periyar, the drainage area of which is 300 square miles, and is undoubtedly sufficient. The estimated rainfall in the Periyar Valley varies between 65 and 200 inches

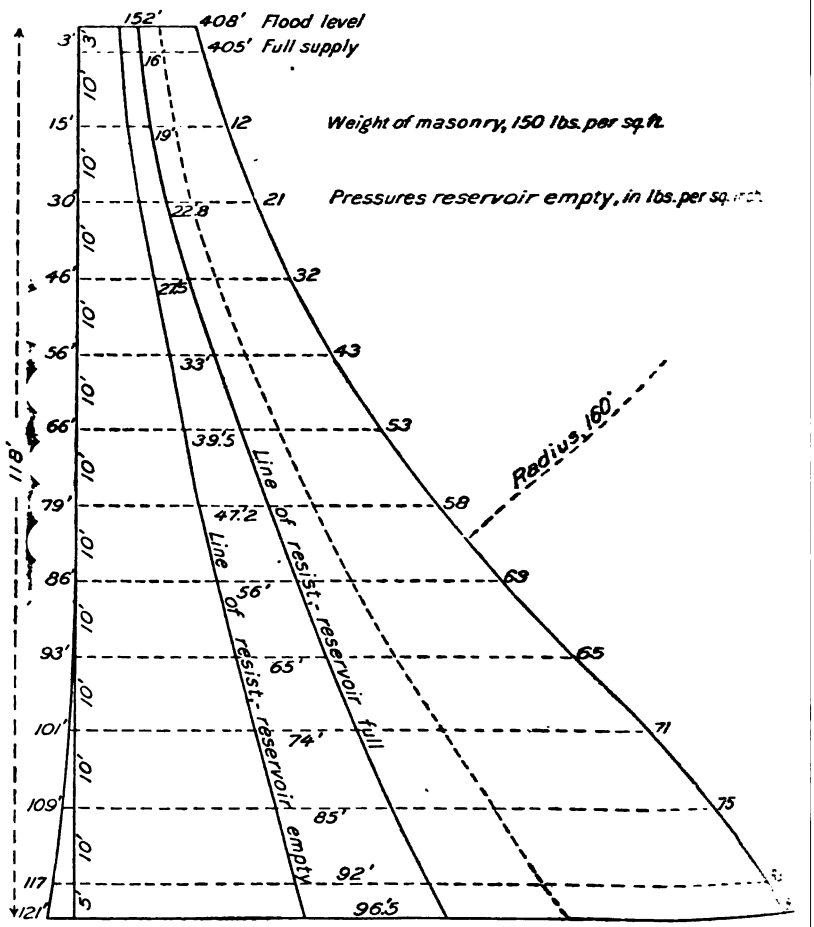


FIG. 54.—Tansa dam, Bombay.

per annum and averages 125 inches, while the depth of run-off in the catchment basin is 49 inches. The estimated discharge of the river available for storage is 760,000 acre-feet, while the loss by evaporation in Periyar Lake and in the beds of the Sooroolly and Vaigai rivers is 70,000 acre-feet, leaving a balance available for irrigation of 680,000 acre-feet. The amount of water required for the irrigation of the lands in the Vaigai Valley is 600,000 acre-feet. It is estimated that

A. FOUNDATION, TANSA DAM.

B. CARRYING STONES TO BUILD TANSA DAM.

over 7,500 acre-feet will be required to fill the beds of the rivers vn which the waters of the Periyar will be passed.

While the maximum storage capacity of the Periyar reservoir is estited at 300,000 acre-feet, the total available storage capacity above sills of the discharge sluices is but 150,000 acre-feet. It was estited that the total cost of this work, including the latest additions he project and interest charges, would amount to $2,894,000, and s sum has been expended. The works were completed within six rs from the time when they were commenced, and the irrigation s expected to be fully developed within ten years after their comtion. The gross revenues are estimated to be $350,000 and the rking expenses and collection charges $62,000. In 1898–99 the ss revenue was $157,000, the working expenses $49,000, and the t revenue $108,000.

TANSA RESERVOIR.

This reservoir is designed not for irrigation, but for supplying water the city of Bombay for domestic uses. It is, however, constructed on the general principles involved in water storage for purposes of

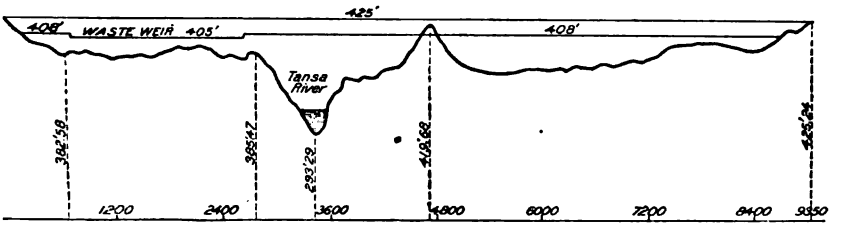


FIG. 55.—Tansa project, longitudinal section of dam.

rigation, and the dam which forms it is of such great size and excelnt workmanship and design that a description of it here will at least e instructive. The project for the construction of the great reservoir n the Tansa River for the storage of water for the supply of the city Bombay was first brought prominently forward by Maj. Hector ullock about 1870. The plans of the reservoir and dam as at present onstructed were worked out and the construction undertaken by Mr. V. Clerke, chief engineer of the water supply of Bombay.

The Tansa River heads near the summit of the Western Ghauts, here the rainfall is great, ranging from 150 to 200 inches per annum. he area of the catchment basin above the dam site is but 52½ square niles, but the slopes are so steep and the precipitation so great in mount that the discharge is estimated to be about 8,000,000 cubic eet per day. The area of the reservoir is 5.5 square miles, at full upply level 405 feet elevation, and the maximum available depth of vater above the sills of the discharge sluices is 20 feet. Its net availble capacity is 59,000 acre-feet, less 18,000 acre-feet, which is equivalent to a loss of 6 feet in depth by evaporation and absorption,

leaving 41,000 acre-feet. The gross storage capacity of this reservoir is far greater than the figures given above, and much more water could be utilized if it were needed for purposes of irrigation by taking off the discharge sluices at a lower elevation.

The dam (figs. 54 and 55) is constructed of the best uncoursed rubble masonry, laid in hydraulic mortar, which is made near the site. The total length of its crest is now 8,800 feet, but may [illegible] be 9,350 feet, of which 1,650 feet are utilized as a wasteway at the south end of the dam. It is constructed in two tangents in such manner as to get the shortest line on a bed-rock foundation. The tangents meet near the center of the dam in a sharp rocky hill which projects a little above its crest. The top of the wasteway [illegible] feet below the maximum flood height of the dam, and the volume of flood which will have to be wasted is estimated to be 25,000 second-feet.

The total cost of this work was about as follows:

Cost of Tansa reservoir.

Compensation for land, etc	$[illegible]
Excavations for foundations, 4,000,000 cubic feet, at 30 cents per cubic yard	[illegible]
Rubble for masonry for the dam, 10,000,000 cubic feet, at $3 per cubic yard	[illegible]
Total	[illegible]

MASONRY DAMS.

It may be generally said that all of the masonry dams constructed by Indian engineers in recent times have been designed according to the most approved modern formulas and the material of which they have been constructed has been almost uniformly uncoursed rubble masonry. The Tansa dam (Pl. XXV) is the most logical instance of the use of uncoursed rubble masonry throughout without any coursed work either in the facing or coping, thus giving an almost homogeneous wall. Mr. W. Clerke, chief engineer of this work, holds that the strains due to shrinkage and settlement in a dam thus constructed are uniform throughout its mass and have little or no effect to rupture it. Whereas in other dams, such as those at Betwa and Bhatgur, where a deep layer of coursed stones has been laid outside of the central core of uncoursed rubble or concrete, the homogeneity of the whole may be destroyed, owing to unequal shrinkage or settlement, thus diminishing the effective cross section of the dam by the amount of the coursed facing.

The Periyar dam is the most logical example of a dam constructed throughout of concrete without any facing or other material to destroy the homogeneous character of the material of which it is constructed. The great dam at Bhatgur is an example of a dam

NATIVES BUILDING TANSA DAM, BOMBAY.

d structure; all of the upper portion of this dam above the lines
:e the limit of pressure exceeds 60 pounds per square inch is
tructed of concrete faced with coursed rubble masonry. Below
point where the limit of pressure of 60 pounds per square inch is
hed, the material used throughout is uncoursed rubble masonry,
d, however, as is the upper portion, with coursed stones. In
ding up this structure the coursed facing and the interior heart-
of concrete were run up simultaneously in layers, and the various
knesses of concrete were bound together by the insertion in them
reat irregular stone blocks which projected above each layer of
:rete as laid. The upper 10 feet of this structure above the high-
er line is composed entirely of a filling of spoil from the founda-
s and this is inclosed between the coursed facing.

he same general mode of construction, a combination of concrete
rubble, was used in the great diversion weir at Vir. The great
r dam at Betwa is constructed of uncoursed rubble masonry coursed
both faces; in addition to this the coping is of the best ashlar.
coursed facing is laid with headers not less than 2 feet long and
tchers, two of which equal in height that of the headers. The
terial used in the rubblework is a kind of igneous granite, very
d and excellent for the purpose. The ashlar work, however, con-
s of hard sandstone. In a few cases brick has been used for the
istruction of low weirs. A notable instance of this is the great
ersion weir at Narora, at the head of the Lower Ganges canal, which
onstructed almost throughout of brick. This material has proved
irely satisfactory, as the Narora weir is not very high and has to
hstand but moderate pressures. The material used in the con-
uction of the Tansa and Bhatgur reservoirs is a heavy trap or
enstone.

The cement used almost universally in the construction of works in
dia is of local manufacture, being made from dirty nodules of lime-
ne which are found in the clay soil distributed very generally
roughout the country. These limestone nodules are called kunkar,
d when burned in a kiln produce an excellent hydraulic lime nearly
ualing the best cement in hydraulic properties and resistance to pres-
re. Ordinarily these limestone nodules are comparatively small.
e best hydraulic cement made from these is that produced near Vir,
the head of the Nira canal. The nodules used for this are scarcely
er bigger than a man's fist. In other places they are much larger,
tably in the Ganges Valley, where the material used in the construc-
on of the Lower Ganges head-works was found in lumps and blocks
eighing some hundred of pounds each. For the manufacture of
ydraulic cement the limestone nodules are burned in a common kiln
ith coke, charcoal, and cinders to hydraulic consistency. This
ydraulic lime is then slaked and crushed, usually by means of the
churus," big stone wheels drawn by oxen, though occasionally in

modern mortar mixers, and is then mixed with the proper proportion of sand, either in the native mortar machine or more usually in an iron mortar mixer.

The stones used in the construction of uncoursed rubble masonry are rarely larger than can be carried conveniently by two men; almost all labor is manual, and rarely is carrying machinery used. The method of quarrying the stone and of transporting it by means of tramways is similar to that employed in America and Europe. The following are a few extracts from notes made by Mr. A. Hill, superintending engineer on the Bhatgur dam, on the masonry construction of that work:

In the facing the masonry is laid in courses, each of which does not exceed [illegible] inches in depth, as large stones are too troublesome to handle. The stones are wetted and the mortar and stones are well rammed. The stones for the rubble are as large as can be conveniently handled by two men, while the smaller stones are broken up for metal to be used in making concrete. In uncoursed rubble the stones touch along their whole sides, not at points or edges merely, and the chips are used to fill in spaces between the larger stones. All awkward projections are knocked off and the stones are well rammed into the bed of mortar in which they are laid, and which must be at least 1 inch in thickness. The average weight of these stones is perhaps 100 pounds.

The concrete is made of broken metal and river gravel, the former 3½ inches and the latter one-eighth to 3 inches; the proportions used are, metal, 16 parts, gravel 16, mortar 12. The concrete is laid in two layers, each 4½ inches in thickness and rammed for twenty minutes and one hour, respectively, and is kept constantly wetted for at least two weeks, that it may set properly. The concrete is made both by hand and machine, the hand mixing being done on a floor with [illegible] the machine mixing in iron barrels or mixers. The stone and gravel are washed before being mixed. Briquets of concrete used on this work, 15 by 10 by [illegible] inches in dimensions, after six months' setting ruptured under a crushing weight of from 400 to 800 pounds per square inch.

In making mortar only sharp, clear, river sand is used. The lime, after being burned to hydraulic consistency, is slaked for five hours, stirred and ground three hours more, and then clean wet sand is added in the proportion of 1 to 1, stirred again for two more hours. For testing, this is made into 2-inch cube briquets, which are kept damp and are allowed to set for forty-eight hours, after which they are placed in water until tested.

The folowing are average tests of mortar made in this way at Bhatgur:

Average tests of mortar at Bhatgur.

Age 12 months, crushing weight per square inch	[illegible]
Age 9 months, crushing weight per square inch	[illegible]
Age 6 months, crushing weight per square inch	[illegible]
Age 3 months, crushing weight per square inch	[illegible]
Age 1 to 3 months, crushing weight per square inch	[illegible]

Some briquettes stood as high a crushing weight as 1,100 pounds per square inch when one year old. The hydraulic mortar used at [illegible] gives even better results. Several briquettes of mortar made [illegible] and mixed in proportion of 1 to 1 and from eight months to one [illegible]

equired a crushing weight of 1,500 pounds per square inch to ıre them. Vir mortar mixed with 2 of sand to 1 of hydraulic breaks at 800 pounds pressure per square inch. The mortar used .e construction of the Tansa dam showed an average crushing gth of 800 pounds per square inch, though numerous specimens ı a test of from 1,500 to 1,800 pounds per square inch.

the head of the Ganges canal in the Northwest Provinces, the rete blocks used for groins in retaining works and for dams are peculiar composition, as hydraulic lime is scarce. They are com- d of 1 part quicklime to 3 parts of broken stone (about 1-inch) and 2 parts of brick dust. These blocks are not very strong hydraulic. At this place the blocks which are used under the r and subjected to the greatest pressure are composed of hydraulic , 2 parts; sand, 1 part; broken stone, 3 parts. The Periyar dam, h, as before stated, is constructed throughout of concrete, is gned to withstand a limit of pressure of 9 tons per square foot. quantities of material have been estimated on the supposition every cubic foot of concrete will require 60 cubic feet of solid e, plus 10 per cent for wastage, to 25 cubic feet of unslaked raulic lime.

DESIGN OF DAMS AND WEIRS.

s stated in speaking of reservoirs and storage works, the Indian ineer designs the cross section of the dam on some theoretic pro- which will be most stable and economical. All of these are sim- to the profile which has recently been discussed and described by Edward Wegmann in his treatise on the "Design and construction masonry dams." Modified formulas, based on Rankine, Delocre, ıntz, or Bouvier, are generally used. Little value has been given methods sometimes adopted of constructing the dam on a plan ved horizontally. None of the high dams seen in India were suffi- ntly short to have been curved in this manner. A formula for the ıign of cross sections which is generally employed by Indian engi- ers is that which was worked out by Mr. Guilford L. Molesworth in 3, and is as follows:[a]

$$Y=\sqrt{\frac{.05\,x^3}{\lambda+(.03x)}}\,;\quad Z=\left(\frac{.09\,x}{\lambda}\right)^4$$

A vertical line being drawn from the top front edge of the dam to ɔ base, Y is the width from this line to the rear face and Z the cor- sponding width from the line to the front face at any distance from e surface of the water or from the top of the dam. Y is further ual to $0.6x$ as a minimum; λ is the limit of pressure of the masonry tons per square foot; H=top height of dam; a=Y at $\frac{H}{4}$ from the p; B=top width=$\frac{a}{2}$.

[a] Roorkee Professional Papers, Roorkee, India, 1883.

The accompanying diagram (fig. 56) shows how this formula applied. It is intended to secure the requisite stability at the f face when the reservoir is empty and at the rear face when it is fu This formula of Mr. Molesworth's, which has created considerab cussion among Indian engineers, is considered an excellent emp formula for general use. Major Pennycuick, who designed the Peri

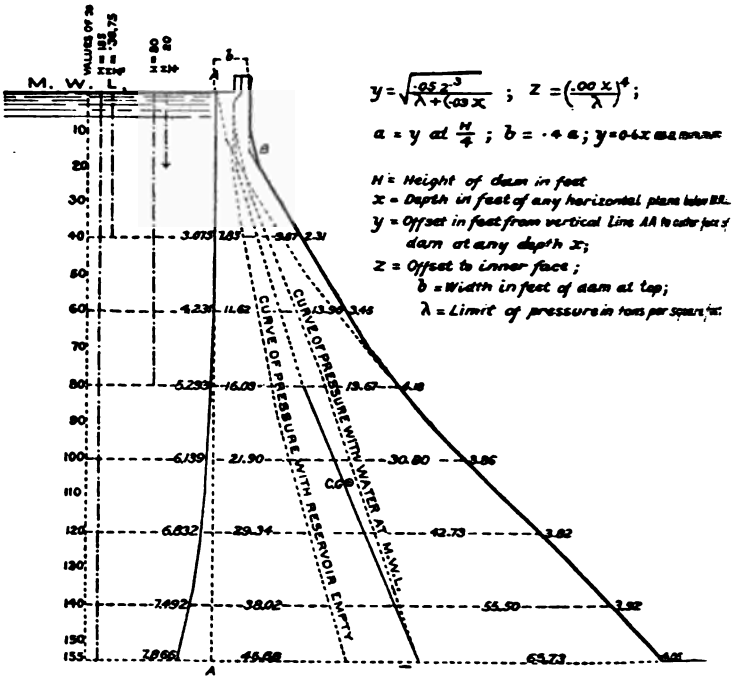


FIG. 56—Profile of masonry dam, Molesworth's formula.

dam, suggested a somewhat different formula,[a] and General Mu in his Manual,[b] proposes a modification of Molesworth's form which may be generally stated as follows:

$$y=b+\sqrt{\frac{.05\,(x-b)^3}{\lambda+.05\,(x-12)}}$$

with $b=12$, or for smaller top widths.

$$y=b+(12-b)+\sqrt{\frac{.05\,(x-12)^3}{\lambda+.05\,(x-12)}}$$

and adjusting the part above $x=12$ to the top width selected.

For weirs with water cushions the depth of the latter is some determined from the formula $D=c\sqrt{h^3}\sqrt{d}$ in which D represent depth of the cushion below the top of the retaining wall; c is a

[a] Periyar project. Records of the Government of India, No. CCXV, Calcutta. 18
[b] Mullins, Lieut. Gen. J., Irrigation Manual, E. & F. N. Spon, London and New York

ıt, the value of which is dependent upon the description of the ·erial used for the floor of the cushion, and varies between 0.75 for ıpact stone and 1.25 for moderately hard brick; h is the height of fall, and d is the maximum depth of the water to pass over the r crest. The width of the floor of the cushion will depend some-ıt on the section of the weir, which need not exceed $8\sqrt{d}$, and uld not be less than $6\sqrt{d}$. For works with a vertical drop and a izontal apron on the same level as the retaining wall, this masonry on should be formed of fairly regular blocks of stone or of Port-d cement concrete, the width varying as just given, and the ·kness or depth of stone from one-fifth to one-fourth of $h+d$.

t is difficult to find any set rule for determining the depth of the ·er cushion by the height of the fall and the volume of water. At Gairsoppa Falls, in the Western Ghauts, the Rajah Fall has a ar drop of 825 feet in height, and the pool into which it falls is 138 t deep at low-water stage. The greatest depth of the hole formed the waterfall in the new outlet of the Mudduk Masur tank is 24 t. In ordinary states of the river the general depth of the water ›hion is to the height of the fall as to 3 to 4 where the greatest ›ion takes place and 1 to 2 in other places. An experimental fall the Bari Doab canal had a height of 6.9 feet and depth of well of eet, and 3.6 feet on crest, which gives the depth of the well to the ·ght of the fall as 3 to 4. The water had no injurious effect on the ttom of the well. The subject of water cushions is one which is t very well understood, though these are very extensively used in dia. They appear to be a most effective and interesting addition nearly every weir where they are placed, greatly increasing its ıbility and firmness.

COST OF LABOR AND MATERIAL.

It has generally been held that owing to the great relative cheap-ıss of labor in India, compared with that employed in the United ates, few lessons, especially of a financial character, could be drawn om a consideration of the results of Indian irrigation works. The ports on the returns derived from Indian works, the percentage of ·ofit gained or loss incurred, are not of the most encouraging char-·ter. A thorough examination of this matter, both in the field and the reports, has, however, allayed any doubts which I had on this ıbject, and leads me to believe that yet better results may be ›tained in the United States, even in comparatively uninhabited ·gions.

As was shown in the earlier part of this report, the returns derived ı India from works constructed with borrowed capital on such works ɜ the perennial canals of the Northwest Provinces show profits arying from 4 to 20 per cent per annum. It was also shown, how-ver, and this is the least promising phase of the investigation, that

in scarcely any case had storage works been profitable. The loss in most cases on this class of works has been trifling, while in several cases a profit has been gained. Moreover, the older works of this class are rapidly becoming more popular. The value of irrigation is becoming better appreciated, even where a constant rainfall occurs, and such works are annually increasing in value.

It was soon seen that any attempt to ascertain the relative value, both cost and return, of works constructed in India by comparison with the rates of labor paid in that country and in America, was altogether futile. Notwithstanding the remarkable cheapness of all classes of native labor, the relations of the laborer to the government, the character of the laborer, and the exhausting heat of the climate, all tend to make his day of labor a relatively short one, both in time and in work done. Few or no mechanical appliances are yet used in the construction of Indian works. It is claimed by some that the seeming cheapness of the labor seduces the engineer. This in most cases is not true. The average engineer appreciates the value of labor-saving machines, but has contended so long with the carelessness of the native laborer and his lack of interest in learning new ways that he has finally given up the struggle of trying to teach him to use modern appliances, feeling convinced that the native cooly achieves as good results in his own way as he could with better apparatus which he would not use or fail entirely to avail himself of.

The long time required in the excavation of works, in filling, carrying, and emptying a little basket which holds perhaps a shovelful of dirt, tends decidedly to make the native labor expensive. The slow mode employed of carrying comparatively small stones for the construction of great dams, consisting of tying ropes around the stones, attaching them to poles, having them lifted onto men's shoulders with the aid of assistants, then making a slow, plodding journey from the stone pile to the top of the dam, all tend to increase the expense of the labor employed (see Pl. XXIV, *B*). In the construction of such works in the United States, machinery would dig the canals in great part and a vigorous, skilled workman, using with intelligence labor-saving appliances, would in a day accomplish many times the amount of work that is done by the Indian cooly. In every individual operation is seen the slowness of native methods. If it be grinding mortar, one walk in a circle drawing a large stone wheel attached to a swing beam, which laboriously and slowly grinds the mortar as the old Mexican arrastre grinds the quartz. Occasionally a modern mortar mill is seen operating beside the native churus and doing in a few minutes the work which the latter take hours to accomplish. In the blacksmith shop half a dozen men are needed to perform the work of one. The forge is blown by a boy, who pumps air through a couple of leather bags beneath his arms, taking much more time to create the same degree of heat than a modern blacksmith's bellows would require.

ıe works constructed in India are invariably of the most substan-
masonry and will last for centuries. Along the roads and rail-
s the smallest bridges and culverts are constructed of stone and
k. On the canals the least important regulator, aqueduct, or
ge is likewise constructed of the best masonry for all time. In
construction of such works, iron and timber would be extensively
l for bridges and aqueducts, or, as we call them, flumes, and for
y parts of the head-works and works along the canal lines, thus
tly reducing the cost.

nother great expense incurred on Indian works has been the effort
ombine navigation with irrigation. This effort has been compara-
ly unsuccessful if viewed from the light of the modern require-
ts of a country possessing good railways and wagon roads. As
ore stated, in order to make the canals navigable their expense is
ıtly increased by the construction of locks throughout the whole
gth and of parallel canal channels; of bridges of greater headway,
rder to admit boats to pass under them; and of expensive aque-
ts or similar works, instead of the cheaper contrivances which
ht be used if navigation were not practiced. Above all, naviga-
ı entails great loss of water.

ı the neighborhood of Poona labor is perhaps as cheap as anywhere
India. It is performed by all classes, ages, and sexes, the more
led laborers, as masons, carpenters, and blacksmiths, usually being
wn men. Most of the burdens, as gravel, sand, mortar, and mate-
s which have been excavated, are carried away on the heads of
nen and children. Common labor is paid about 8 cents per day.
sons and carpenters get from 16 to 20 cents a day, while a laborer
h a team of bullocks gets 25 cents a day. On the Bhatgur dam
ıkeys and bullocks were frequently used as pack animals for carry-
stones and earth. A donkey will carry a cubic foot of stone per
and earns 6 cents a day. Common laborers were paid 8 cents,
men and children 4 cents, and skilled laborers 20 cents per day.
was estimated that 8 skilled masons could lay and dress 3 cubic
rds of masonry per day on this work. Owing to the slow mode in
ich the work was conducted it was necessary to employ a great
mber of laborers at one time, so many in fact, that a large portion
them were frequently idle through interference with one another.
out 2,000 men, women, and children were engaged on small portions
the dam at once and the daily rate of progress was about 5,000
bic feet of rubble and concrete work and 1,000 cubic feet of course
asonry facing.

At Tansa the work was done by contract, and the prices paid were
little higher than elsewhere. Rubble masonry cost $3 per cubic
rd. On Lake Fife and Bhatgur the same class of good uncoursed
bble masonry cost but $2 per cubic yard. On the Tansa dam over
000 people were at work at one time. On the Betwa canal earth

excavation in deep cuts, not exceeding 40 feet in depth, cost but cents per cubic yard; surface excavation in earth with short haul 3 cents per cubic yard; uncoursed rubble masonry cost $2.30 per cubic yard; coursed rubble masonry, $6.25 per cubic yard, and dressed ashlar work $22.50 per cubic yard. On the Periyar works the ordinary price of unskilled labor was 12 cents per day; for special work, such as feeding machinery, etc., the coolies were paid 20 cents per day, while head coolies, artisans, etc., were paid from 30 to 60 cents per day.

All kinds of material other than those found in the country are most expensive in India. Coal is usually brought from England at a cost never below $20 per ton. Iron, steel, and machinery are relatively very expensive, as is Portland cement and wood of every kind. In fact, masonry work is generally cheaper than wood, and iron is always dearer than masonry. The great cheapness of masonry is owing to two causes—cheapness of labor, and cheapness of the hydraulic lime which is manufactured in the country almost invariably near the site of the work which is being constructed. On the Periyar work drilling cost $10 per hundred running feet of drill hole, and the labor of quarrying, including plant, boring, dynamite, and all other expenses, amounted to about 85 cents per cubic yard, as much as it would in the Western States of America. On the same work in tunneling, the heading cost $6.50 per cubic yard, and the enlarging the tunnel $2.60 per cubic yard was paid; lime cost [illegible] per cubic yard, sand 40 cents per cubic yard, and concrete cost [illegible] per cubic yard laid in place. Of minor items, the removal of [illegible] or cutting cost 6½ cents per cubic yard, steel 15 cents per pound, and wrought iron 8 cents per pound. On the Sidhnai Canal, in the Punjab, concrete cost $1.80 per cubic yard, rubble masonry $2.[illegible] cubic yard, and brick 95 cents per hundred laid in lime mortar. Earth excavation cost 4½ cents per cubic yard, and the best hydraulic lime cost $2.50 per cubic yard to manufacture.

TANKS.

Tanks were constructed in great numbers by the natives of India many centuries ago, and in some places, notably in central and southern India, in the Deccan, Madras, and Mysore, there are immense numbers of them. These old tanks were usually rude in construction, little care having been taken to economize in labor, and as a consequence the dams constructed were usually made much heavier in cross section than was necessary. In recent years the British engineers have constructed several very large tanks, though many of the higher dams have masonry cores. The conditions controlling the location of a tank are similar to those before described for reservoirs. The water supply must be adequate to fill the tank, the location must be such that a suitable dam can be constructed at a reasonable cost, and an ample wasteway must be provided. In the location of

teway for a tank, even more care must be exercised than is neces-
r for a reservoir; for if the water be permitted to rise too high on
dam—or much worse, if it is allowed to discharge over it—it will
edily cause its destruction if it is built of earth.

t is desirable always to allow waste water to flow off by a side chan-
, which may be closed by a low rock or crib-work weir, or may con-
only of an open rock cut. By such means there is no danger to
dam of having the shock of water falling over it. It may, how-
r, be necessary to have a masonry wasteway constructed in the
n itself, but this is not advisable and is generally avoided. Such
'asteway is usually made by constructing a portion of the dam of
sonry, the top of which is a few feet lower than the rest of the
n. When the catchment of the tank is small it is possible to pro-
le for wasting flood waters through an outlet or discharge channel
the dam itself. Such a discharge sluice is necessary in order to
aw off the water for irrigation, and must be of sufficient capacity
empty the tank in the shortest irrigating season. The level of the
l of this outlet sluice is generally that of the bed of the tank, but
ere are occasionally constructed one or more higher outlets to irri-
te lands which lie above that level. These sluices are expensive
rks, and require a well-constructed masonry or iron conduit to be
rried through the dam, emptying into the canal at one end and
eiving its water supply at the other end through a well or water
wer from which its admission can be controlled. It is usual to make
e outlet tunnel of good masonry, and it must not be smaller than
feet high by 2 feet wide, in order to permit a man to go through it
examine, clean, or repair it, if required.

One cause of the frequent breaching of Indian tanks is that great
mbers are often constructed in one valley, the bed of one begin-
ng where the cultivation of that of the next above it ends, so that
e breaching of one often results in the destruction of a succession of
ose below it. Regarding the depth of tanks, if they be shallow a
eat loss of the stored water is sustained through evaporation. Shal-
w tanks are never intended to hold more than water enough for one
op. In India aquatic plants which grow from the bottom in shallow
nks are injurious, while those which spread on the surface, like the
tus, diminish the loss by evaporation. When water is not deeper
han 7 or 8 feet the rays of the sun can penetrate to the soil, and
rowth of aquatic plants is the consequence. In the smaller tanks,
ntended to cultivate limited areas of land immediately below them,
he most economical height for the dam on gently undulating ground
vhere there is a natural and long slope to the rear has been found to
e from 10 to 25 feet.

In the construction of modern tanks the same precautions are usually
aken and the same detailed investigations made as for a reservoir
project. The catchment basin, the discharge of the streams, the rain-

fall, and other physical phenomena are carefully studied; the lands to be irrigated are examined and their relative position to the location of the tank and catchment basin is surveyed and mapped. Careful surveys are made for the reservoir site to determine its capacity, and of the dam site in order to choose the best and most economical location and to ascertain the cost of the works.

The interior and exterior slopes of earth dams are usually considered as planes, forming together an angle of not less than 90°, and the figure should be so formed in order to increase its stability, that lines of pressure passing from the interior faces at right angles may fall within its base. Upon the calculation that 1 cubic foot of rammed earth weighs [illegible] pounds and 1 cubic foot of water 62½ pounds, and supposing that the earth would stand at any slope, we find that the base of the prism resisting the lateral thrust of the body of water does not require to be more than two-thirds the depth of the column it supports, so that all quantities above that are due to the natural slopes, the stability of the dam, and the prevention of percolation. Consequently when large works are projected it is a subject of close calculation which is the most economical, those exclusively of earth or those whose inner slopes have retaining walls of masonry.[a]

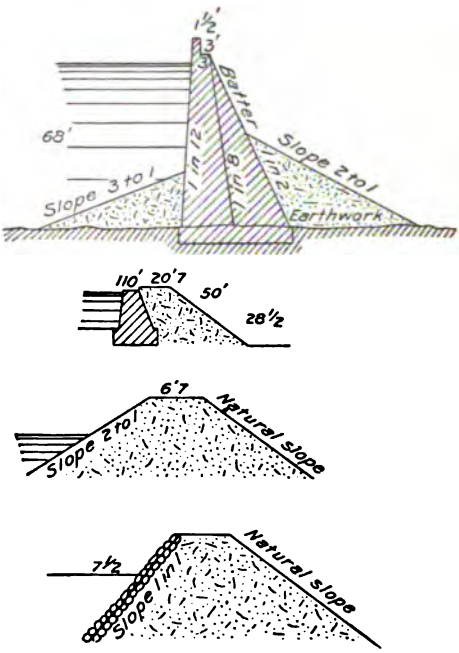


FIG. 57.—Cross sections of earth and combined dams.

As constructed in India, the width of the top of the dam depends not so much on the pressure of water it has to sustain as on the prevention of percolation. The usual width now allowed is from [illegible] feet, thus giving room for a roadway. The top of the dam is made sufficiently high above the highest line of flood over the sill of the wasteway to prevent its being topped by waves. On a large sheet of water a strong breeze forms waves sometimes 3 feet high, which on a long slope may be raised to 5 feet. The dam must be of such height that water can not pass over it, as the latter would quickly scour away the back slope until the thickness was sufficiently reduced to cause the dam to give way. Additional security against

[a] Victor, H., Notes on irrigation in the Bombay Presidency: Roorkee Professional Papers, Indian Engineering, Roorkee, India.

ı an accident is obtained by raising a low masonry parapet on outer edge of the slope, paving the top, and giving it a slight dip ırd to prevent the settlement of water.

he number of disused tanks is remarkable. Many are not ıched, but the discharge sluice is left open so that no water is ected. In many cases this is probably owing to the bed of the c having been gradually raised by silting and thus converted into roductive a soil that it yields as much as or more than could be ıined by means of a diminished quantity of water applied to the ıparatively barren soil below. An example of one of these old ks thus abandoned, but capable of restoration, is the Madag sur tank, believed to have been constructed about four centuries . It was formed by an embankment rising from the sides of a row gorge through which the Choardy River passed, and was plemented by two dams in saddles on a range of hills, that on the t bank 1,350 yards and that on the west 760 yards from the main n, the length of the latter being 1,650 feet. The inside slope of 1 2½, in some parts 1 on 3, was revetted with large stones up to a ›ic yard in bulk. This dam is from 945 to 1,100 feet wide at the se and is now from 91 to 108 feet high. There was a sluice under dam at the east end above the level of the ground. The material which the dam is constructed is a strong red earth with a con- erable mixture of gravel, and was taken from the sides of a hill in e neighborhood. The east supplemental dam has its base 74 feet ove the sluice in the main dam, and had also a sluice under it at e ground level. The west supplemental dam, the breaching of ıich destroyed the tank, was of similar construction to the others, d its base was 60 to 70 feet above the bed of the tank. There was trace of any wasteweir, and it is probable that the want of this ıs the cause of the ruin of the tank. From the heights of the ıms and the levels of the sluices it is probable that the depth of the nk was 90 to 95 feet, and at that level its area would have been 40 uare miles and its contents about 870,000 acre-feet of water.

Another variety of tanks, constructed not on main drainage lines or reams but in depressions in a flat country, are usually closed by a ifferent form of dam. There were many of these, and large numbers e breached or abandoned and their beds now cultivated. The nbankments of these flat-country tanks are often of great length, ot unusually 1 or 2 miles; that of the Veeranum tank is 12 miles ›ng, and the ruined bank of the Puniary tank in the Trichniopoly istrict is said to be 30 miles long. The height of these is generally ıconsiderable, being in many hundreds of cases only sufficient to hold rom 6 to 10 feet of water. A few of these works, however, are 20 or 0 or even 50 feet in depth. The inner slope is generally revetted with tone and has an inclination sometimes of 1 on 1, oftener of 1 on 2 or nore. The height of the bank above the water level varies. For

instance, the Nundyal tank has a dam at one place 18 feet high above the water level, 16 feet wide on top, with an inside slope of 1 and an outside slope of 1 on 2. The Kolevoy tank, in the district, has a bank 36 feet high, extending 9 feet above the level, a top width of 12 feet, and equal slopes inside and outside 1 on 1½.

As the accumulating alluvial deposit made year after year gradually raises the beds of tanks, these would become filled up were not some expedient adopted from time to time, such as adding to the height of the dam. This, however, generally involves an enlargement of the cross section as well as the raising of the wasteweirs and the construction of new sluices at higher levels than the one occupied. The expedient frequently resorted to successfully is to have the mud stirred up by hand at the beginning of the rainy season when the flood waters are permitted to carry it off through the discharge sluices. This, however, is only partially effective, like the scouring of the undersluices in a reservoir.

In central India there are many tanks; their history is rather modern and is very interesting. In 1820 the Mairs, a tribe occupying Marwar, Meywar, and Ajmere, were banditti living in the hills constantly fighting and making raids on the Rajputs and other neighboring tribes. The Mairs lived chiefly by levying blackmail on isolated hamlets and on travelers. Col. H. Hill subjugated them, and by the establishment of a government, police, etc., caused them to live more peaceably and to commence the pursuit of agriculture. In 1835 Colonel Dixon succeeded to the charge of the Mairs and arrived at the conclusion that the lack of water, rendering agriculture impossible in a country whose rainfall was below 20 inches, was the cause of their predatory life. Their history from this time was similar to that of the nomad and bandit tribes which occupied the country now irrigated by the Sirhind Canal in the Punjab. Colonel Dixon commenced by causing the construction of terraced irrigation lands by means of retaining dikes, and of tanks by means of earth or masonry dams.

Having been furnished with an abundant water supply for fertilizing the crops, the Mairs have, owing to this enlightened policy of Colonel Dixon, now become peaceful and industrious cultivators. The small tanks furnish water for irrigation below them and water for wells near them, and when the water is drawn off their beds are cultivated and, being very fertile and moist from the deposition of sediment, produce excellent crops. These tanks now support a large population and produce considerable revenues.

The following table exhibits the principal dimensions of some of the Mairwara tank embankments and weirs:[a]

[a] Smith, R. Baird, Italian Irrigation, William Blackwood & Sons, London, 1855, vol. 1, p. [illegible].

Dimensions of some of the Mairwara embankments and weirs.

Name.	Length of embankment wall or weir.	Breadth— In foundation.	Breadth— At upper surface.	Depth of foundation.	Height above foundation.	Spread of water.	Area irrigated, including cultivation in bed.	Cost.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Acres.*	*Acres.*	
a	620	27	10	9	24	182	204	$3,125
ja (escape weir added to ient embankment)	251½	28	.....	6	16	218	364	1,890
ana weir	522	10½	3½	0	18	25	36	1,100
Kuncur	3,369	42	6	0 to 10	28	182	437	8,275
na	460	25	4½	10	28	94	250	2,135
r weir, upper	240	30	7	8	36	72	109	2,000
ower	343	12½	6½	10	20	72	29	1,280
anee	575	29	.....	20	24	218	273	810
la Bura	954	5	3½	6	14	36	83	.....
atan	1,333	21	.....	19	16	145	328	.....

'he following table exhibits the results of some of the works detailed ve, showing the increase in number of families, of wells, and of age tanks, etc., during eleven years preceding the preparation of onel Dixon's report, 1835 to 1846:

Results of Mairwara embankments.

Name of village.	Increase in number of— Families.	Wells.	Village tanks.	Increase in revenue.
bra	38 to 133	3 to 46	0 to 31	$235 to $1,030
waja	25 to 122	8 to 28	0 to 15	125 to 895
lee Kunkar	0 to 118	0 to 25	0 to 14	0 to 545
rar	70 to 440	131 to 301	.....	1,925 to 4,425

The following table shows the whole number of tank embankments nstructed in Mairwara up to the date of the report:

Tank embankments in Mairwara.

Districts.	Number of embankments and weirs.	Spread of water in bed.	Area irrigated, including cultivation in bed.
		Acres.	*Acres.*
jmeer Mairwara	158	6,323	10,557
ewar Mairwara	120	3,077	3,960
arwar Mairwara	12	275	309
Total	290	9,675	14,826

From the above it will be seen that between the years 1835 to [illegible] the increase in the number of wells was from 2,230 to 6,150, or [illegible] The increase in the number of tanks was from nothing to 2,0[illegible] estimated population increased 60,000 (from 40,000 to 100,000), and [illegible] revenue increased from $48,000 to $105,000, or $57,000. The estima[illegible] sums expended under the sanction of the government in all Mair[illegible] during the same period of years was $125,000, while the aggre[illegible] increase in land revenue for the same period amounted to $32[illegible]

Lieutenant Home, in 1868,[a] reported on six principal tanks in Ma[illegible]wara the average capacity of which ranged from 920 to 2,400 acre-[illegible] The total outlay on these to the end of the year 1866 was $40,000. [illegible] net income to the end of the same year was $2,000, or a net gain v[illegible]ing between 1 and 12 per cent. The results of Lieutenant Ho[illegible] inspections showed that not only have Colonel Dixon's works [illegible]mously benefited the country, but they have returned the governm[illegible] 150 per cent on the expenditure incurred. The whole of the six [illegible] especially mentioned paid nearly 10 per cent on the capital inv[illegible]

In Mysore in southern India there are 37,000 tanks, of whi[illegible] Robert Temple says:

> Wherever there is a depression in the land an embankment with a wa[illegible] and a sluice is thrown across it. The water is held up above it, and below it [illegible] acres are sown with rice and sugar cane, and irrigated by means of sluices. [illegible] few yards lower down the depression comes another, and so on, increasing [illegible] as they go on until a series of tanks may consist of more than one hundred [illegible]nected together, the overflow from the wasteweir of each being the chief [illegible] of the one below it and the stream that issues from the wasteweir of the [illegible] one being a river in magnitude. The tanks at the top of the series are mere [illegible] and those at the bottom are often good-sized lakes, and the area irrigated by [illegible] is frequently very large.

In Madras Presidency, including Mysore, there are said to be ab[illegible] 75,000 tanks. All of the smaller tanks are repaired either by the [illegible]lages or by the landowner. The smaller tanks are used durin[illegible] rainy season chiefly in order to keep up a constant supply of wa[illegible] the fields during the intermission of the rainfalls. The larger [illegible] contain water supply sufficient often for one year and sometim[illegible] several years. In Mysore, early in 1866, Major Sankey[b] reported [illegible] the percentage of the whole area of Mysore under the tank syste[illegible] 59.7, while the total area of the state is 27,300 square miles. U[illegible] under exceptional circumstances, none of the drainage of 60 per [illegible] of this area or 16,300 square miles is allowed to escape, or [illegible] should, with proper attention, be allowed to escape, were all exi[illegible] works in their normal condition. To such an extent has the pri[illegible] of storage been followed that it would now require some ingenu[illegible] discover a site within this great area suitable for a new tank. In [illegible] Major Sankey said that "one-third of the tanks then existing in My[illegible]

[a] Home, Lieut. F., R. E., Tank irrigation in Ajmeer and Mairwara: Roorkee Pro[illegible] Papers, No. 229, Roorkee, India.

[b] Sankey, Maj. R. H., R. E., Irrigation in Mysore: Roorkee Professional Papers on Indian E[illegible]neering, Roorkee, India.

'e large irrigating reservoirs." He found about one tank to the ıare mile and one village to the same area; the average quantity of tivation was about 10 acres to a tank. In this area there are some at tanks, such as the Mudduck and Nuggar tanks mentioned elsee ere.

'he ordinary Mysore tank is, however, a much smaller description work, usually closed by a low and long dam; an average one being ›ut 12 feet broad at top, 60 feet wide at bottom, and 18 feet high. this description of tank the sluice is usually a large, substantial, l not infrequently expensive work. It consists of a square brick or ne cistern, 2 yards each way and 1 yard high, to keep off the sand the entrance of the sluice, with one or more valves or plug holes in tone at the bottom, from 6 inches to a foot in diameter each. The lve is attached to a long pole which is held in an upright position 2 or 4 vertical stone pillars, to which horizontal projections are ached, one at top and another midway down, through a hole in the ıter of which the valve rod works. The pressure of the water upon e top of the valve keeps it sufficiently tight when lowered into the valve le to prevent the escape of water. At the rear of the dam another ›tern of about the same dimensions, and usually of brick in mortar, built, three sides of which are furnished with square openings and utters to permit the water being turned off. The two cisterns are nnected by a tunnel, the length of which depends upon the cross ·tion of the dam through which it is laid.

Most tanks receive their supply from the high ground in the neigh- ›rhood; but there are exceptions to this, as numerous tanks are ,rtly supplied by channels, either from water courses or canals, which ,nd around remote hills and catch the rain flowing down their sides ıd convey it to the tanks. A single tank may possess several feeders this kind. Many old tanks which had failed during the early native ›vernment have been restored by the British engineers; others which ere decayed have been repaired, and a few which were tolerable have ›en put in perfect order. None of these irrigation works have dete- orated since the British took possession, and their condition on the hole has been greatly improved. Judging from various reports the orks are probably now in a more effective condition than at any :her time of which we have a record, and the increase in efficiency ıs apparently kept pace with the increased liberality in the expendi- ıre, taking no account of the great rise in labor rates of late years.

In the Madras Presidency mainly, exclusive of Mysore, there were ›ported in 1882 to be 53,000 tanks, having about 30,000 miles of mbankments and 300,000 separate masonry works, weirs, escapes, tc., yielding a revenue of $7,500,000 per annum, and having invested n them a capital of $75,000,000. In 1882 the area irrigated for first or ›et-weather crop amounted to 2,525,790 acres, and the area of autumn ›rop irrigated in the same year by tanks amounted to 675,400 acres. ›ome of these Madras tanks are, as before stated, of immense size.

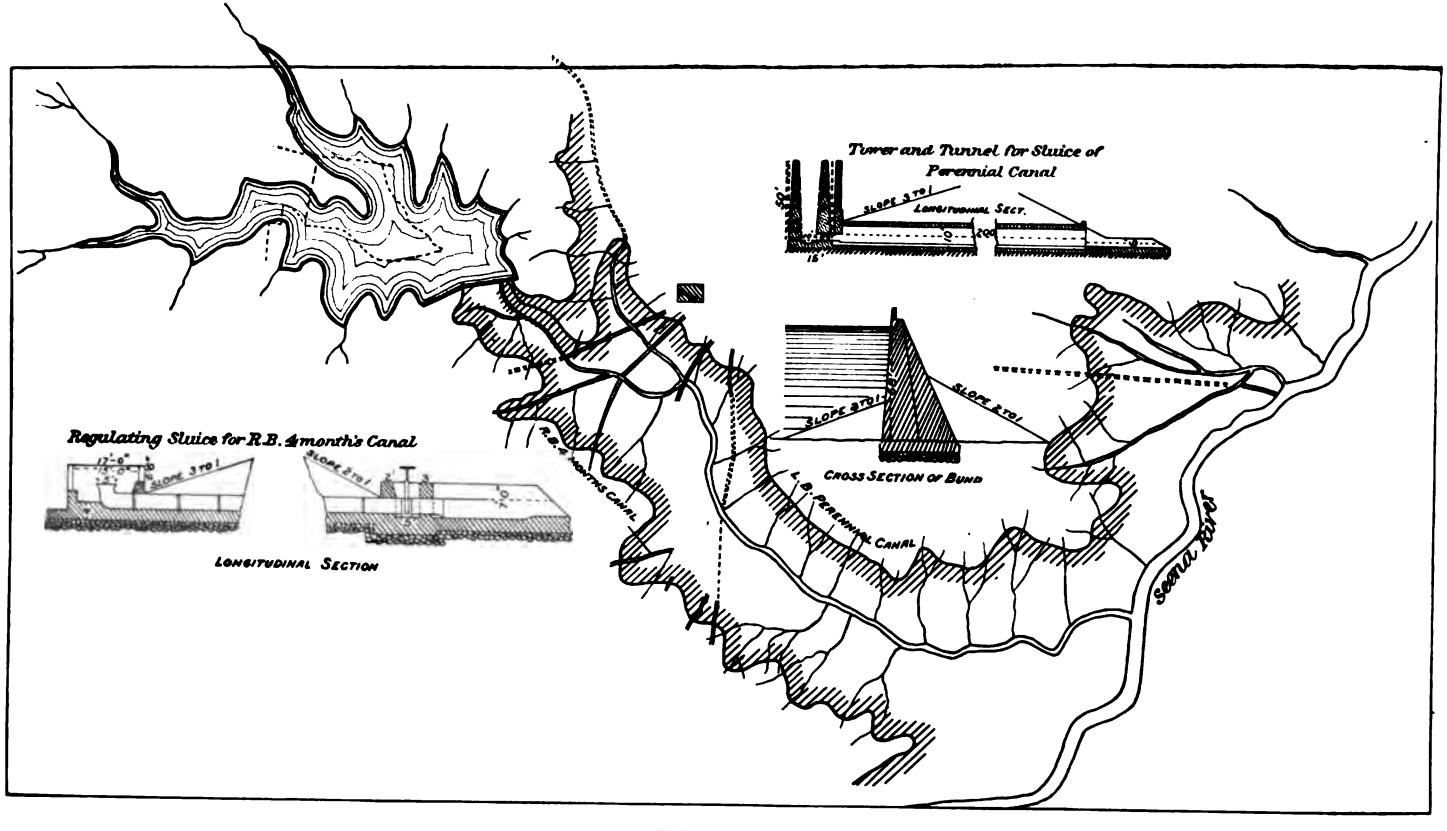
The Virainum tank, which is a very ancient work, has an area of [illegible] square miles and an embankment 12 miles long. It is still in full operation and returns an annual revenue of $57,000. The Chembrambaukam tank in Chingliput is so large that it resembles a great natural lake. Its embankment is more than 3 miles long, and its wasteways have a total length of 676 feet of escape. Its gross capacity is [illegible] acre-feet, its surface area is 8.95 square miles, or 5,730 acres, and it irrigates of wet-weather crop 12,760 acres, and of autumn crop [illegible] acres. The dam which closes this reservoir ranges from 9 to [illegible] feet in thickness at the top, and from 16 to 28 feet in height, and is constructed of earth. It supplies irrigation to the fields by means of [illegible] separate sluiceways. In 1882 the capital invested in this work had reached $312,000, and the revenue for that year amounted to $[illegible]

Some of the most interesting tanks to be found in India, because they are the most modern, are several of the great tanks recently constructed in the Bombay Presidency, which are more truly reservoirs than tanks, as the latter term fails to convey a proper idea of their magnitude and importance. Of these, the more important and interesting now in operation are the Ekruk tank near Sholapur, and the Ashti tank, also in the Sholapur district, and constructed on the Ashti River.

The following table gives some of the more important data connected with these tanks, and is derived from the Bombay revenue report for 1900–1901:

Tanks in Bombay Presidency.

	Ekruk.	Ashti.	[illegible]
Area of catchment ..... square miles	159	92	[illegible]
Average annual rainfall ..... inches	30.7	26.7	[illegible]
Available contents ..... acre-feet	76,130	32,660	[illegible]
Surface area ..... acres	4,551	2,380	[illegible]
Area commanded ..... do	17,152	17,882	[illegible]
Area irrigated ..... do	16,941	11,780	[illegible]
Main canal ..... miles	48	27	[illegible]
Distributaries ..... do	.....	2	[illegible]
Height of dam ..... feet	76	57.7	[illegible]
Total cost ..... dollars	953,000	278,000	1,17[illegible]
Area irrigated:			
Autumn ..... acres	1,620	989	[illegible]
Summer ..... do	1,355	1,440	[illegible]
Total ..... do	2,975	2,420	[illegible]
Percentage double cropped	1.2	6.3	[illegible]
Discharge utilized ..... second-feet	33.3	9.3	[illegible]
Area of autumn crop irrigated per second-foot of discharge utilized ..... acres	40.8	155.8	[illegible]


Tower and Tunnel for Sluice of Perennial Canal
SLOPE 3 TO 1
LONGITUDINAL SECT.
Regulating Sluice for R.B. 4 month's Canal
SLOPE 3 TO 1
LONGITUDINAL SECTION
R.B. 4 MONTHS CANAL
SLOPE 3 TO 1
SLOPE 3 TO 1
CROSS SECTION OF BUND
L.B. PERENNIAL CANAL
SEONI RIVER

EKRUK TANK.

EKRUK TANK.

he catchment area of the Ekruk tank is 159 square miles, on which annual rainfall averages 24.7 inches and the run-off 41,400 acre-, or 4.87 inches per square mile. The rainfall on the irrigable ls served by this tank averages 22.8 inches per annum, the duty he water supplied during the four months' autumn crop was 76 s per second-foot, and the water rate charged on the land served ing the year 1888 was 86 cents per acre irrigated or $73 per second- of discharge at the canal head. The crops raised in 1888 were ributed about as follows:

Crops raised on land irrigated from Ekruk tank.

Crop.	Acres.	Value.
eat	337	$3,100
ar	260	17,300
let	344	2,307
ns	537	2,700
Total, including all others	2,976	38,000

This work was undertaken by the Indian government and is situ- d 5 miles northeast of the town of Sholapur. The scheme, drawn in 1863 and sanctioned in 1866, comprises a tank formed by an rthen dam and supplying three canals for irrigation. It receives water supply from the River Adhila, a tributary of the Lina, the ll of which is 7 feet per mile, and its greatest flood discharge is ,000 second-feet. The dam which forms the tank has a total length 7,200 feet, including 2,730 feet of masonry, of which 1,400 feet is at e northern end and 1,330 feet at the southern end. The maximum ight of the earthwork above the bed of the Adhila River is 72 feet, 7 feet above the highest flood line. The height of the masonry rtion is 3 feet above the highest flood, exclusive of 3 feet of parapet ove that. When full the maximum depth of the tank is 60 feet, and s contents 41,700 acre-feet of water, the surface area of which is 6⅓ uare miles. The wasteway is at the northern end of the dam, and nsists of a channel 250 feet wide carried through a spur and dis- arging into a side drainage course. The calculated maximum elocity over the wasteway is 10 feet per second, and its capacity of ischarge is 250 by 5 by 10 = 12,500 second-feet. The depth of evapo- ation during eight months is 7 feet, and the loss amounts to 17,250 cre-feet.

This tank has three discharge canals. The accompanying Pl. XXVI ives some details of this work. The lowest or perennial canal is 28 niles long, and its sill is 20 feet above the level of the bottom of the ank. Its discharge amounts to 44 second-feet and it covers an irri-

gable area of 25 square miles. The next canal above this is intended to provide a four months' supply of water; it is 18 miles long and discharges 42 second-feet, and covers an irrigable area of 21 square miles of land. The highest canal is also calculated for a four months' supply, and is 4 miles long and discharges 21 second-feet of water. The discharge of one of these four-months' canals is compensated for by the supply of rain received during the rainy season. The lower perennial canal is taken from the left bank, the second canal from the right bank, and the higher canal from the left bank. The discharge sluice at the head of the perennial canal consists of a masonry tunnel through the canal bank, with a substantial masonry inlet tower on the water side. The diameter of the tunnel through the dam is 12 feet and its total length is 200 feet. The discharge sluices for the four-months' canals consist of an iron pipe 145 feet in length and 5 feet in diameter through the dam, which is closed at the lower side by means of a valve worked by hand gear from above.

According to the revenue report for 1900–1901, the total outlay on the Ekruk tank to the end of that year amounted to $953,000, the total receipts from irrigation during the year were $3,040, and the gross receipts from all sources amounted to $8,030; the total working expenses amouted to $2,660, showing a net revenue of $5,370, equivalent to 1.2 per cent on the capital outlay. As originally designed this work was estimated to yield a net revenue of 9 per cent on the capital expended. Its failure to do this is largely due to the small demand for the water, owing to the natural rainfall on the district served being ordinarily sufficient to raise crops without irrigation.

ASHTI TANK.

The catchment area of this tank is 92 square miles, and the rainfall over this area averages 24.1 inches per annum; the run-off amounts to 8,000 acre-feet per annum, or 1.62 inches per square mile. The rainfall on the irrigable lands served by the tank averages 19.8 inches per annum. The project comprises a tank on the Ashti River, formed by an earthen dam 12,709 feet long and 58 feet in maximum height, having a total storage capacity of 34,500 acre-feet of water. There are two discharge canals, one on each side of the Ashti River, which extend to its junction with the Bhima River and command 25,270 acres of irrigable land.

This work is situated in the Sholapur district, about 16 miles southwest of the town of Madha. The project was originally prepared by Capt. C. B. Penny, R. E., in 1869. In 1876, when the great famine was imminent and the prosecution of relief works was urgently called for, this was one of the first works undertaken for that purpose. The project (fig. 58) was then thoroughly revised and complete plans and estimates prepared by Mr. Charles T. Burke[a] under the orders of Col.

[a] Burke, Charles T., The Ashti tank: Proceedings of the Institution of Civil Engineers, vol. [illegible] part 2, 1888, London.

Merriman, R. E., chief engineer. The available capacity of the is 32,660 acre-feet, and to furnish this quantity a run-off of 6.3 es per annum would be required from the catchment basin. The off during an average season is but 6 inches, or 4.87 per cent of available capacity of the tank. The features of the ground, how-, do not admit of the capacity of the tank being reduced, as the l of full supply was regulated by the only saddle available for the teway. Had that been lowered the quantity of rock excavation essary would have cost more than the earthwork required to raise dam, besides which there is manifestly an advantage in making reservoir of large capacity if it can be done without increased ense.

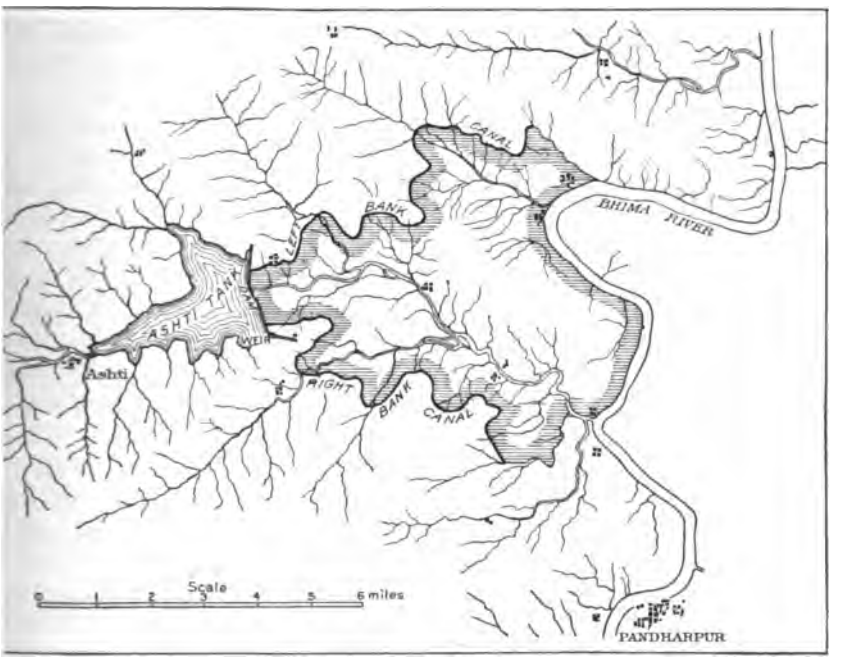


FIG. 58.—The Ashti tank and canals.

The loss by evaporation, absorption, etc., was estimated at 4 feet in epth on half the area at full-supply level. From actual experiment fter the completion of the work it was found that the loss from evaporation in 1880 during the six winter months of dry weather was 3.8 eet; deducting this quantity the net supply of water available for rrigation is 25,300 acre-feet.

The total length of the dam is 12,709 feet. Its top breadth is 6 feet, ts breadth at full-supply level is 42 feet; the side slopes above this point are 1 on 1½ below it, the inner slope is 1 on 3, and the outer slope 1 on 2. Previous to its construction the site of the dam throughout was cleared of vegetable and loose material, and the sand and silt were removed from the entire area forming the site of the dam in the

river bed. Thus the dam throughout rested upon a sound and firm foundation. There is no puddle wall, but a puddle trench, the filling of which rises 1 foot above the ground surface, extends throughout the whole length of the dam, and is 10 feet in width, and has been excavated down to a compact impervious bed. Its composition is [illegible] parts sand and 3 parts of black soil. The central third of the dam is built up of selected material of black soil extending, as shown in the accompanying illustration (fig. 59), in a triangular section, from the dam crest, where it is 6 feet wide, to the base, where it is [illegible] feet wide. Outside of this are two triangular sections composed of the brown soil of the country, and this is faced outside with from 1 to 15 feet of puddle of sand and black soil, while a similar puddle on the inner slope is paved with 6 inches of large stone pitching to enable it to resist wave action. Across the river bed a trench 5 feet in width was excavated along the entire length of the dam down to the rock and extending 100 feet into the banks of the river. On each side this was filled with concrete and was connected with the puddle trench. The puddle trench was curved around the concrete wall and continued across the river at a distance of 20 feet from the concrete wall on the upstream side.

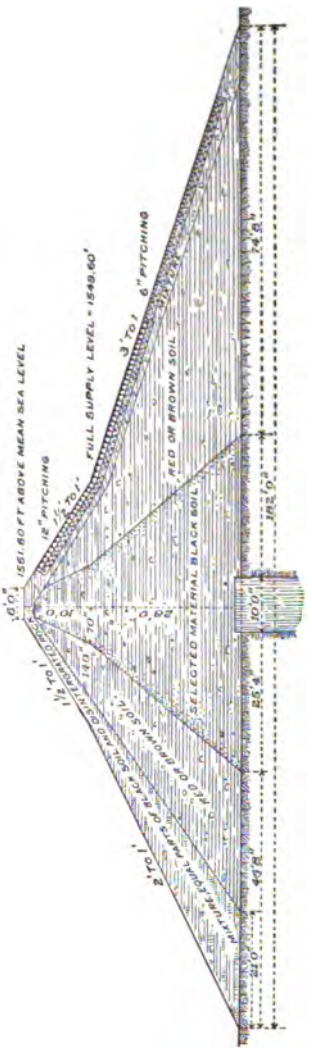


FIG. 59.—Aahti tank dam.

The following procedure was adopted in completing the foundation of the dam in the river bed. The puddle trench and concrete wall having been finished during the dry season, measures were taken to utilize the floods of the ensuing rainy season to assist in clearing away the sand, silt, etc., from the site in the river bed. Piers of loose rubblestone were disposed in rows upon the upstream side of the site; these were about 5 feet in diameter and were placed about 40 feet apart. During breaks in the wet weather the sand to be removed was plowed and thus more readily acted upon by the scouring action of the floods, which flowed with a high velocity through the contracted water area between the piers

caused the removal of a large quantity of sand from the site at a ll expenditure. A low dam of dry rubble work was then con- cted across the river about 100 feet above the site to prevent it n again being silted up, and during the dry season the work was ied up in the ordinary manner.

he pitching given to the inner slope of the dam was calculated as ows:

he thickness of the pitching depends upon the greatest height of waves to which the dam is exposed, and the maximum height of waves depends upon the "fetch" or distance from the shore ere their formation commences and was determined by Stevenson's nula

$$x=1.5\sqrt{F}+(2.5-{}^{4}\sqrt{F})$$

ere $x =$ the height of wave in feet, $F =$ the fetch in nautical miles. ain, Rankin states that where an embankment of loose stone is osed to the action of waves it must be faced with blocks set by nd, the least dimension of any block in the facing being not less n two-thirds of the greatest way height. From these two consid- ations the thickness of the pitching was deduced.

The cross section of the Ashti dam is considered to be amply strong every way, yet Mr. Burke deems it well to consider whether in rks of such magnitude the adoption of a more liberal cross section uld not be advisable. He says that the Ekruk tank dam has a top eadth unnecessarily great and not uniform, as it is diminished in oportion to the height. This does not improve the appearance of e dam, is unnecessary under any circumstances, and involves an creased outlay. The top breadth of the Ashti dam is too narrow, r, although sufficient in strength, Mr. Burke considers it objection- le for various reasons. A dam of this kind would warrant, if but r appearance alone, as well as for the convenience afforded by a adway, a small outlay to increase its top breadth sufficiently. In eparing the plans of the Pangoan tank which was subsequently signed by Mr. Burke, the top breadth was increased to 8 feet, and en this appears insufficient for a dam 77 feet in height. Mr. Burke commends the following as a minimum top width for works of this ature in India: For earthen dams 50 feet in height and over, top readth to be 10 feet; under 50 feet in height, 8 feet. In the course f time settling may occur in dams constructed wholly of earth, ren- ering repairs and renewals necessary. In the first ten years after he completion of the Ekruk dam, 2½ feet in depth of new material as added to its top, and this could not have been properly rolled olid if the roadway had not been sufficiently wide for compression by heavy roller.

The change of inclination from 1 on 2 to 1 on 1½ of the outer slope f the Ashti dam is undesirable. As regards the inner slope, the incli-

nation of 1 on 3 up to the level of the estimated maximum f[illegible] appears to be good. This should then change in tanks to 1 on 1[illegible] the top of the dam. It is a matter for consideration whether the u[illegible] part should not be 1 on 1, rather than 1 on 1½. It would probab[illegible] an advantage, Mr. Burke thinks, that waves should be reflected ra[illegible] than broken on the slope, and on the authority of Mr. Scott Russ[illegible] appears that a slope of 1 on 1 will reflect waves, while on flatter s[illegible] they are broken. The cross section recommended by Mr. Burke [illegible] general adoption in India is as follows: The height of the dam ab[illegible] the full-supply level, or the crest of the weir, is $h=d+x+c$; in wh[illegible] d = the depth of water in the tank above the weir-crest level whe[illegible] maximum flood is flowing over the weir; x = the height of the top [illegible] pitching above the surface of the maximum flood in the tank, fo[illegible] by the formula previously given; and c = a constant of the value [illegible] or 3 feet according to circumstances—that is, the vertical heigh[illegible] the top of the dam above the top of the pitching.

The wasteway of the Ashti dam consists of a channel having a c[illegible] width of 800 feet excavated through a saddle in the high ridge con[illegible] tuting the western boundary of the tank. The bed of this chann[illegible] which is excavated in rock, is level for a mean length of about [illegible] feet and then falls away, with a slope of 1 in 100, toward the Ra[illegible] Torrent, into which the flood waters are discharged, and thus pass i[illegible] another valley distinct from that draining the tank. The discha[illegible] capacity of this wasteway is 48,000 second-feet, which will cause t[illegible] water to rise 7 feet above its sill, or within 5 feet of the top of the da[illegible] The discharge capacity of the wasteway was calculated as follows:

L=width of channel=800 feet.

d_2=the depth of water in the channel=3.5 feet.

The surface slope of the channel being 1 in 100, the mean veloc[illegible] is as follows:

$$v=92.26\sqrt{\frac{h}{e}\times d_2}=17.25 \text{ feet per second}$$

and the corresponding discharge is 48,300 second-feet. The head [illegible] water in the tank necessary to cause a discharge of this volume [illegible] determined by the formula

$$D=C_d\,L\,d_2\sqrt{2gd}+\tfrac{2}{3}C_d\,Ld\sqrt{2gd}$$

where d_2 is the depth of the channel and the constant $C=75$.

The Ashti tank was designed as a minor productive work, the [illegible] outlay on which to the end of 1901 amounted to $278,000. The re[illegible] nues from irrigation in that year amounted to $1,780 and the g[illegible] revenues to $2,040. The working expenses during the same ti[illegible] amounted to $14,500. This excess expenditure, however, was lar[illegible] due to additional works. There was earned, in fact, a net reve[illegible] of 1.46 per cent on the capital outlay.

TANK DAMS.

ral Mullins in his Manual of Irrigation[a] lays down some dif-
·ules for the top width and various dimensions of an earthen
›m those above quoted from Mr. Burke. He says that the top
›f an earth dam should not be less than 4½ feet anywhere, and
hat width will suffice for the ends of dams of comparatively
· tanks, the width at the deeper part of these should be
ed to 6 feet. From 9 to 12 feet will be a proper top width for
dams, and for very large ones one-fourth of the depth of the
s the prescribed minimum for the deeper parts and 8 feet at
ls. The top of the dam, the upstream slope of which is revetted,
always slope toward the rear edge, so that the rainfall may
f down the rear slope and not on the revetment, with the risk
hing out the back of the latter; 1 on 16 for earth and 1 on 24
ıvel will be suitable grades for this top slope. The grade of the
›r or front slope will depend upon the description of protection
ıt wash to be provided, revetted slopes ranging from one-third
›n 1; for shingle, slopes of 1 on 2 or 2½ are suitable. The gradi-
r the exterior or rear slope will vary according to the nature of
il from 1 on 1½, which is the steepest allowable, to 1 on 3.
ıouthern India at or near the center of the dam is considered the
›osition for a puddle wall. It is of primary importance that the
should not crack during the considerable periods of each year
:he tanks are either dry or the water in them is at a low level.
naterial most used for puddle walls in Madras is clay of the
iption used for tile making. It is well tempered and a puddle
: not too wet. Any excess of moisture beyond that needed to
·of the entire wall being worked into a homogeneous mass increases
isks arising from settlement. The top width given to puddle
ı, whatever their height, is about 2 feet, and the top level is made
1 to 2 feet below the level of the top of the dam. Batters of from
1 to 8 on 1 are given to the faces of the puddle wall. The thick-
of the wall at the base, that is, at the ground level, is usually
d by the formula $2+\frac{2h}{b}$ in which h is the height from the ground
ıe top of the wall and b is the batter. The foundation of the wall
'equently of concrete down to an adequate depth below the ground
'ace, viz, to 1 foot at least in clay or impervious soil and to 4 feet
nore or less pervious soils. The cross section of the foundation
ıch is made as wide at top as the base of the puddle wall and some-
ıt narrower at the bottom, being cut with side slopes of 3 or 4 on 1.
'evetting water slopes of dams a suitable backing of small stone
ı gravel is always placed beneath the revetment of uncemented
ne.

Mullins, Lieut. Gen. J., Irrigation Manual, E. & F. N. Spon, London and New York, 1890.

In designing the surplus weirs or wasteways the quantity of wa- to be gotten rid of must first be ascertained. The length of w- required is usually ascertained in Madras either from tables or calculation with the formula for weirs:

$$D = L \times \tfrac{2}{3} cd \sqrt{2gd}$$
$$= L \times \tfrac{2}{3} c \times 8.02 \sqrt{d^3}$$

which, with $c = .6075$ (a value applicable to very many tank work- comes $D = 3.25\, L \sqrt{d^3}$, in which D is equal to the discharge in se- feet; c is a coefficient, the value of which varies with the form of weir, but seldom exceeds 0.65; d is the maximum depth in f- water to be allowed to pass over the weir, and $2g$ is a cons- representing the force of gravity.

As of interest, showing how even earthen dams which are -structed in a most substantial manner may slip or subside from - unexpected cause, the following is a description of the slips wh- occurred in the Ekruk and Ashti dams. The full-supply level of Ekruk dam has a thickness of 91 feet, and at the maximum ca- lated flood level its thickness is 41 feet. From the date of its com- tion in 1869 until September, 1872, the dam was perfectly sound - in good order, but in that month excessive rain fell all over tha- of the country in which the dam is situated. From 9 to 14 inch- rain were gaged at different places in the catchment area betw- the 19th and 23d. The water on this occasion rose to 6 feet over - crest of the waste weir and at the same time three slips occurred - the rear slope of the dam. Colonel Fife, the chief engineer, at once vi- ited the tank and reported that the slope of the embankment wh- the earth had slipped or been washed down was not vertical, but w- about 45°, and this for about 10 feet only, after which it became fla- No leakage whatever was observed through the dam. Prior to - accident dry stone drains had been constructed at an angle down - rear slope to carry off the rains and prevent scouring of the embank- ments; it was thought that these drains at the site of the slips - become choked or had sunk, owing to the saturated condition of - soil, and had thus allowed the water to accumulate and escape, wash- ing away the earth below. These drains on the slope were accordin- done away with, the dam was carefully made up to its original s- tion, berms were constructed to weight the toe of the dam at the - of the slips, and surface drains were cut to carry off the slight leak- under the dam.

No further accident occurred to this dam until the summer of 1- when another slip took place, coincident with heavy rain on the ca- ment basin. The position of this slip was directly in continuatio- one of the slips of 1872, the rear half of the dam having for an a- age length of 188 feet subsided vertically about 8 feet. This por- of the embankment was founded principally on black soil which h-

ne saturated, resembling a pulpy mass, and had been forced ırd by the pressure of the dam. To remedy this a dry stone ning and draining wall was constructed at the toe of the dam at ide of the slope. This wall was sunk 8 feet into the ground and 10 feet wide at the bed; cross drains were also cut to drain this ıe direction of the creek below the bank, and a counterfort or ı 45 feet wide and 10 feet in height was raised on the toe of the ankment to counteract, by its weight, the tendency to bulge ard.

ırly in November, 1883, owing to excessive rains, the water in the ti tank rose 1 foot over the crest of the wasteweir; shortly after ıall horizontal crack about 40 feet in length was observed in the hing on the front slope, and it was immediately repaired by remov- the stones, tamping the bank, and relaying the pitching. About eek later a crack 3 inches wide and 4 inches deep was found in rear of the slope. This crack had a horizontal length of about 60 , and ran down the slope to a level of about 10 feet below full- ›ply mark. It was at once repaired, but on the following day it pened, when a settlement at the top of the dam was observed. ›m this time for several days top continued to subside and ; ground at the toe of the dam bulge upward. Equilibrium s not established until a week er. The total settlement of ɜ top of the dam amounted to feet, bringing it 4 feet below the full-supply level of the tank; the tched slope, however, remained intact up to about 4 feet above this ;el.

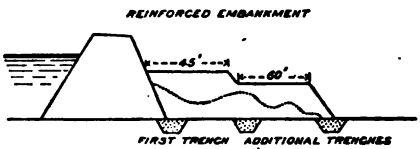


FIG. 60.—Ashti dam slips.

The causes of the slips resemble in a measure those of the slips at e Ekruk tank. A considerable length of the dam is founded on a ay soil, with nodules of dirty lime in it, and generally contains a ıantity of alkali which causes it to become semifluid when soaked ith water. It is probable that at the site of the slope the excavation ›r the puddle trench had not been made quite deep enough to pre- ent leakage of water under it. The length of the slipped portion at ıe top was 155 feet. The dam at this point is 44.3 feet in height and t the time of the accident the water was standing 31.7 feet deep at his point.

The permanent corrective measures adopted after the cessation of he movement were the digging of a trench at the toe of the rear slope vhich was filled with bowlders and broken stone (fig. 60), as was lone for the Ekruk dam, heaping the excavated material and other earth on to the bulged-up ground to counterbalance the lifting action, remaking the dam to its original section, and adding earth and broken stone to give additional weight to the rear slope. The drainage trench

has been extended along the slope wherever the foundation was [illegible] to be treacherous and this has been supplemented by additional [illegible] similar in character and running parallel to it, and two coun[illegible] or berms have been added to the slope all along the rear portion [illegible] dam, about 700 or 800 feet in length, to weigh the toe.

COMBINED STORAGE AND CANAL SYSTEMS.

Several combined storage and canal systems have already [illegible] described in their proper places. The Nira project, the Ber[illegible] tem, the Periyar system, and the larger tanks just described [illegible] combined systems of storage works and irrigating canals. Th[illegible] two other combined systems which differ from these in their [illegible] characteristics and should be described as of peculiar interest. [illegible] the Palar anicut system in Madras, whereby the water from the [illegible] River is furnished to a number of tanks by means of main and [illegible] supply channels and is stored in these tanks until wanted for [illegible] of irrigation. The other is the Zhara Karez irrigation sch[illegible] Beluchistan, by which a number of small detached tanks situ[illegible] the bottom lands adjacent to the Machka Torrent are filled by [illegible] nel intercepting the subsurface flow and by channels taken fr[illegible] torrent to the tanks during portions of the year when there is [illegible] water in the stream.

PALAR ANICUT SYSTEM.

The Palar anicut or wier was originally designed to give an im[illegible] supply to old channels which fed a series of old native tanks [illegible] situated on the Palar River, 4 miles below the town of Arcot, a[illegible] a catchment basin above it of 3,974 square miles, the maximum [illegible] discharge from which is 25,000 second-feet. Anicut is a Tam[illegible] which means literally wier, and the Palar anicut is a simple [illegible] sion wier constructed across the Palar River whereby water is d[illegible] on both banks of the river into the supply canals which head [illegible] the wier.

The irrigation which commenced in 1853 with an area of [illegible] of wet-weather irrigation and 700 acres of dry-weather irr[illegible] extended until 1882, when there was an area of 66,700 acres of [illegible] weather and of 20,600 acres of dry-weather irrigation. The rev[illegible] nue derived from the system previous to the end of 1882, inc[illegible] the enhanced land revenue, was $290,000 or 36.5 per cent [illegible] amount of direct charges. The amount of interest charged [illegible] same date, however, was $670,000.

The weir itself (fig. 62) is 2,634 feet in length between win[illegible] and 7 feet high with a vertical fall, and is founded on a suita[illegible] of circular wells. There are three aprons, the first of cut [illegible] mortar 36 feet wide, and the third of dry rubblestone 30 fe[illegible] The under sluices on the north side of the river consist of 22 [illegible] 5 by 5 feet each, those on the south side of 10 vents of the [illegible]

ensions. The weir was breached for a length of 1,015 feet by the ls of October, 1874, previous to its final reconstruction. The nnels on the north are the Mahendravadi channel supplying the k of the same name, and the main channel which branches into supply channels, one at 3 miles from the head and the other at niles from the weir. From this last channel other branches are en off which terminate in various tanks. On the south side are ee channels. The project has not realized the anticipations origin- formed because the supply in the river bed was overestimated, ides which there were considerable defects in the channels them- ves as originally laid out.

The water records show that on an average there are 273.7 days arly on which no water is registered. The northern channels

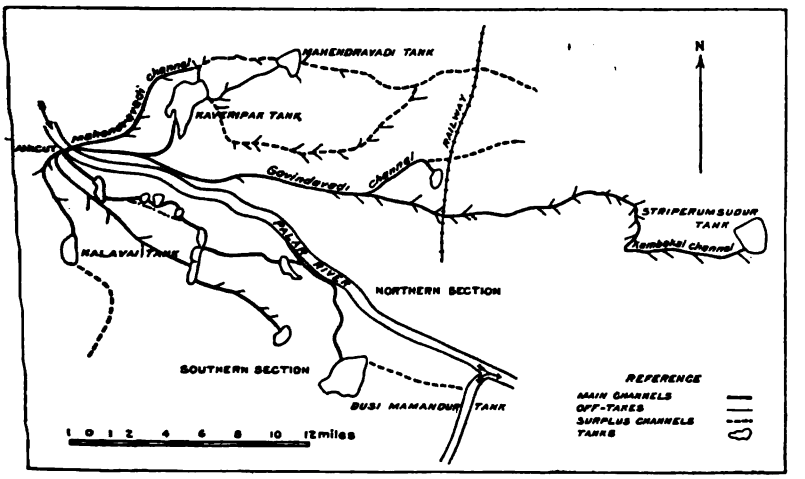


FIG. 61.—Palar anicut system, showing main channels and offtakes.

receive a full supply when there is 5½ feet on the sill of the weir under sluices, and the southern channels not until there is 7 feet on that side.

The Palar River rises on the Mysore plateau and runs into the ocean after a course of about 220 miles. There is extensive irrigation from it by means of river channels, which are chiefly provided with masonry heads. The weir supplying the system here described is built at the one hundred and fifty-second mile, and is situated about 4 miles below the famous town and fort of Arcot. The drainage basin of the river to this point is about 3,974 square miles, the maximum flood discharge about 25,000 second-feet, and the maximum depth of flow passing over the weir 6.75 feet, as before stated.

There is little or no direct irrigation from the main or branch channels. In almost every case the water is first let into the tanks in which it is stored. These are frequently of large size, as the Kaveripak tank on the northern and the Dusi Mamandur on the southern side, which irrigate 5,870 and 3,050 acres, respectively. As at pres-

ent constructed, the system contains on the northern irrigating 38,260 acres, or about 300 acres per tank irrigating 14,750 acres, or nearly 200 acres per tank, o side. On of these, filled by many of the large supplie local drainag is conveyed to various channel

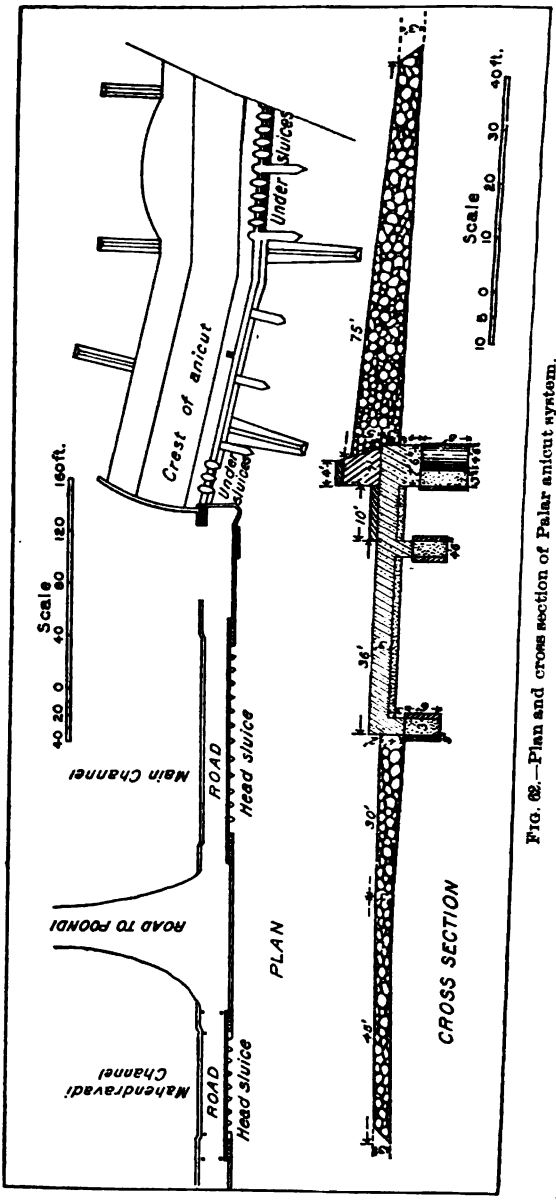


FIG. 62.—Plan and cross section of Palar anicut system.

The Palar Riv extremely objecti one for the supply large irrigation sy The northern n sluices receive a supply only durin average of 22.6 day each year, as the l are 1½ feet above sills of the north sluices. The carr capacity of the north main canal is not than 3,140 second-f It is 215 feet wide, ries 4 feet in depth water, and has a fa 3 feet per mile. T southern main canal 113 feet wide, carries feet in depth of wat and has a fall of 6 feet per mile with a di charge of 2,300 second feet. Combining the results with the num of days during wh the water supply available it will be se that the northern chan nel carries 140,000 acre feet during the period of full supply and the southern channel 65,000 acre-feet. These are assumed as the volumes which determine the area capable of being irrigated.

A. RUSSELLKONDA HEAD SLUICE.

B. RUSSELLKONDA DAM.

RUSSELLKONDA TANK, RUSHIKULYA PROJECT.

he Rushikulya irrigation system consists of two canals drawn n the Rivers Mahánadi and Rushikulya, which are tapped by ani- s built at the heads of those canals, and the supply further supple- nted from two reservoirs, the Russellkonda and Suradá. The ssellkonda is formed by damming up a valley in the basin of the hánadi and supplying it by an anicut and channel from the Gulleri 'er, one of the affluents of the Mahánadi. The Suradá reservoir is istructed across the Pathama River, one of the affluents of the shikulya. The length of the Mahánadi canal is 19 miles, while it of the Rushikulya to the Chatrapur-Berhampur road is 57 miles. The dam (Pl. XXVII, *B*) is entirely of earth, carefully worked in 'ers with a puddle wall through the center and carried up to within feet of the top of the bund, as it was considered essential to con- ue it above a point where there was less than 15 feet of water essure at F. T. L. The front slope is carried up on an average of o-thirds of the height of the dam at a slope of 2:1 and from that int at a slope of 1:1, and revetted with stone-pitching 2½ inches in ickness. The rear slope is 2½:1 up to the same height and then is ought up in the ratio of 1½:1. The rear slope is turfed throughout ith a berm varying from 10 to 50 feet wide at the point where the 'eak in ratio of slope occurs. The settlement throughout has been erfectly uniform, and no slips or dangerous percolation have as yet curred. The maximum height of the dam is 75 feet and depth of ater 58 feet. Its contents at F. T. L. will be 2,295 millions of cubic et, and it can be supplied from the Gulleri River in thirty-eight ays.

The head-sluice (Pl. XXVII, *A*) is built of table-molded bricks nd ashlar string courses and ashlar vents. The vents, three in umber, are closed by cast-steel shutters worked from a platform by rdinary screw gearing with ball-friction bearings, and can be raised ithout difficulty by six men against the maximum head of 42 feet of vater. The anicut is of the usual form adopted in the Madras Presi- lency, with a clear drop wall 6 feet in height, with an upper masonry pron, and longitudinal retaining walls, all founded on wells, with a acked rough stone and an adjustable loose-stone apron below.

The Mahánadi canal head-sluice and scouring sluices in juxtaposi- ion thereto are built of random rubble and pointed with surki mor- tar. The sluices are fitted with shutters and screw gearings. The Janamalli anicut, built at the rear of the Rushikulya canal, across the river of the same name, consists of a main body wall and a sloping talus of rough stone, with one longitudinal retaining wall and an adjustable loose-stone apron below. The water from the Mahánadi canal, being passed into the Rushikulya, is arrested by the anicut and diverted through the Rushikulya canal head-sluices, twelve in num-

ber. The Godahallow aqueduct, consisting of 15 arches across the river of that name, is 40 feet wide and will carry a maximum depth of 8 feet of water. The side walls are of random rubble in [illegible] mortar and the arches of brick in surki mortar. A depth not exceeding 3 feet has been passed over it, sufficient for present requirements of the irrigation below.

ZHARA KAREZ IRRIGATION PROJECT.

This scheme proposes to store in detached small tanks the water supply which runs in the Machka Torrent for a month or so in spring. The site of the scheme and the catchment basin of the torrent are

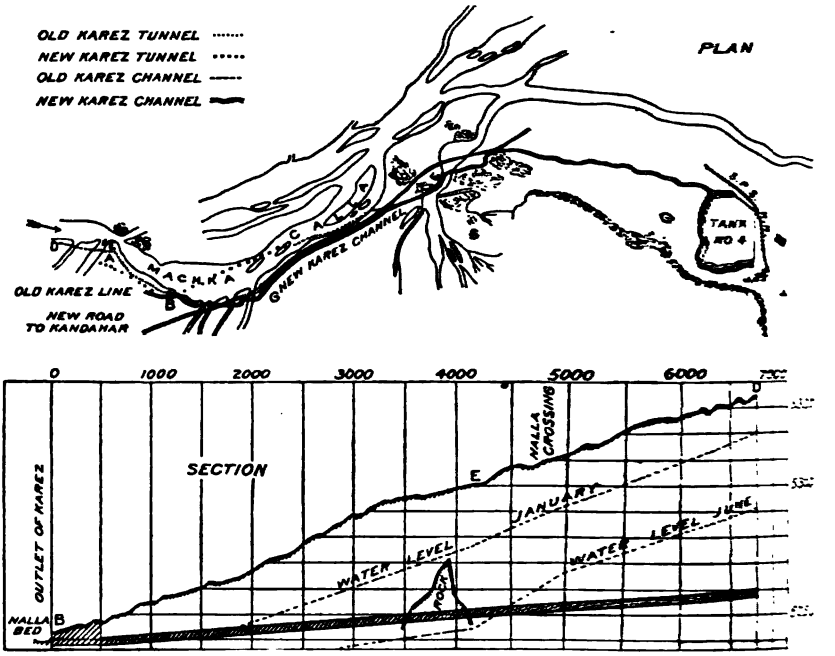


FIG. 63.—Zhara Karez irrigation project, Beluchistan.

Beluchistan, in the neighborhood of Khojak Pass. In the winter a [illegible] snow generally falls on the hills and after melting filtrates through the shale and runs off in springs lower down. The bed of the torrent has a slope seldom less than 1 in 70 where it leaves the hills; a short distance lower down its bed deepens until it is about 30 feet below the surface of the plain. There is no possible site for a large reservoir and accordingly five small sites for tanks were selected. About six of the last twenty years there has been no winter supply in the stream. In summer there are occasional heavy showers, but the floods last but a few hours and little or none of their water can be stored. The tanks are to be filled by small water courses leading from the stream (fig. [illegible]) and the water will then be utilized about the 1st of May in giving

ial watering to rain-sown wheat crops, as the spring rains are generally sufficient up to that time. When empty, the beds of the tanks will be utilized for small crops without irrigation. There are no distributing canals, as in no case is anything larger than a large private water channel necessary.

The tanks are all on a comparatively small scale, the maximum depth having been fixed at 12 or 14 feet. As no clay was available for making puddle, the top of the bank is 3 feet above the full supply level, and the inside slopes are either pitched with bowlders or planted with willows. The outlet sluice is a simple concrete wall with numerous holes 0.8 of a foot in diameter placed at various depths and closed by wooden plugs, which can be opened by hand from a movable ladder resting on top of the well. From the bottom of the well a culvert leads under the embankment with stop walls on the outside. There is scarcely any local drainage to any of the tanks, and hence no large escapes are necessary. As a precaution the top of the well is only carried up to the full supply level.

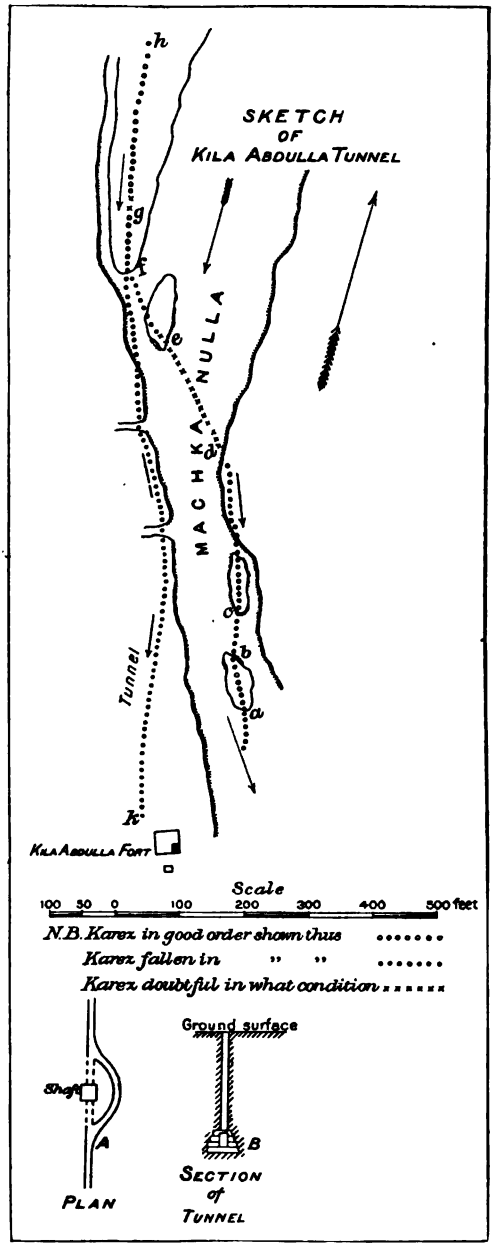


FIG. 64.—Machka Nulla Karez.

The total amount of water available in the tanks for purposes of irrigation, after deducting losses by absorption, will be 1,550 acre-feet, and this is estimated to be sufficient to irrigate 2,570 acres; from which deduct about 30 per

cent for the bad years, when there will scarcely be any rainfall, the average acreage irrigable during the dry season will be about 1,500. To this may be added 200 acres of wet-weather crop sown in the tank bed. The total cost of constructing this system of tanks is estimated as being $2,800, and the total revenue is estimated to be 75 cents per acre, from which it will be seen that the scheme as a whole is estimated to pay 4 per cent.

In 1887 the construction of tank No. 4 was authorized, in addition to which a tunnel 5,800 feet in length was authorized to be constructed under the stream channel, with shafts at every 50 feet and curved passages around each shaft, with a short piece of open excavation 900 feet in length. From the last shaft to the surface of the ground is an open channel 2,500 feet in length to connect the tunnel with tank No. 4. The object of this tunnel is to intercept the subsurface drainage and thus insure a supply to the tank, which will immensely increase its utility as an irrigating reservoir.

For many generations there has been an old tunnel at this site which frequently fell into decay and disuse until again cleaned out. Its alignment is shown in the accompanying illustration (fig. [illegible]). About the year 1883 a portion came to grief through a flood finding its way down some of the shafts, and since then it was not used until its repair was proposed in 1887. By the latter part of 1887, 4 shafts and a half mile of the tunnel had been completed. The water-bearing stratum had been reached and a discharge of half a second-foot obtained. The old tunnel worked with a constant discharge of 9 second-feet for forty years. As the new channel is better located and in better soil, it is estimated to give at least as good results as the old one did. The slope of the tunnel is 3 in 1,000, the sections 3 by 1.7 feet, or, say, 5 square feet, which with a mean velocity of 1.8 feet per second will give a maximum discharge of 9 second-feet.

The estimated cost of this work is nearly $4,000. The rates paid were 10 cents per lineal foot in depth of shaft and 20 cents per lineal foot of horizontal tunnel, the excavation being entirely in earth. The returns estimated are as follows: Discharge, 9 second-feet; area irrigable by 1 second-foot or duty, 150 acres; rate per acre, $1.[illegible]; gross revenue, about $1,600. The maintenance charges will amount to practically nothing.

CHAPTER IX.

RIVER TRAINING AND LAND RECLAMATION.

RIVER CONSERVANCY.

In connection with all irrigation works maintained on the great ains and deltaic rivers of India, river training and improvement orks must be constructed in order to maintain the stream in the annel which will cause it to do least injury to the various irrigation orks. During seasons of flood the branches of these great rivers ange, as does the Missouri River, tearing into enormous tracts of e surrounding country, and they would, if not properly guided, estroy great portions of the canal and remove hundreds of acres of aluable irrigable land. In addition to this destruction of property, ey cause severe inundations during the times of flood, which destroy aluable crops and property.

These inundations, when of small magnitude and confined within easonable limits, do little harm and even much good may result from hem. They do not increase the healthiness of the neighborhood, ut the silt deposited by the water tends to fertilize the land, hus enabling richer crops to be produced with much less trouble. Autumn crops which lie along the edge of inundations of this minor lass are usually defended by earth embankments, which are often niles in length. These embankments are of no great height or olidity, and are merely built in comparatively shallow water to save he crops, but inundations of greater magnitude, where the waters attain great force and extend through the heart of a large district, lestroying houses, bridges, and canals, and washing away land, are of another kind. In providing a remedy for this class of inundation the engineer must possess great skill and patience.

The planting of Nanel grass, which is a long, coarse variety of water grass, when the plantations are properly arranged and progressively made, gives one of the best means of reclaiming parts of the river which are beyond the proper boundaries of the waterway. This grass thrives in the streams of India, the cost is much less than that of any other treatment, and the reclamation is performed by the action of the river itself, by the deposition of silt due to the reduction of the current, so that water highly charged with silt at the upper end of a plantation is often found to issue from the lower end with little or no discoloration.

Above and below the head-works of the Lower Ganges canal at

Narora the river flows through a low bottom land which is limited at some distance back from its banks by a bluff about 60 feet in height. It was immediately found necessary to construct training works to prevent the stream from cutting into this bottom land, thus turning the end of the weir from above, or perhaps cutting into the bank and

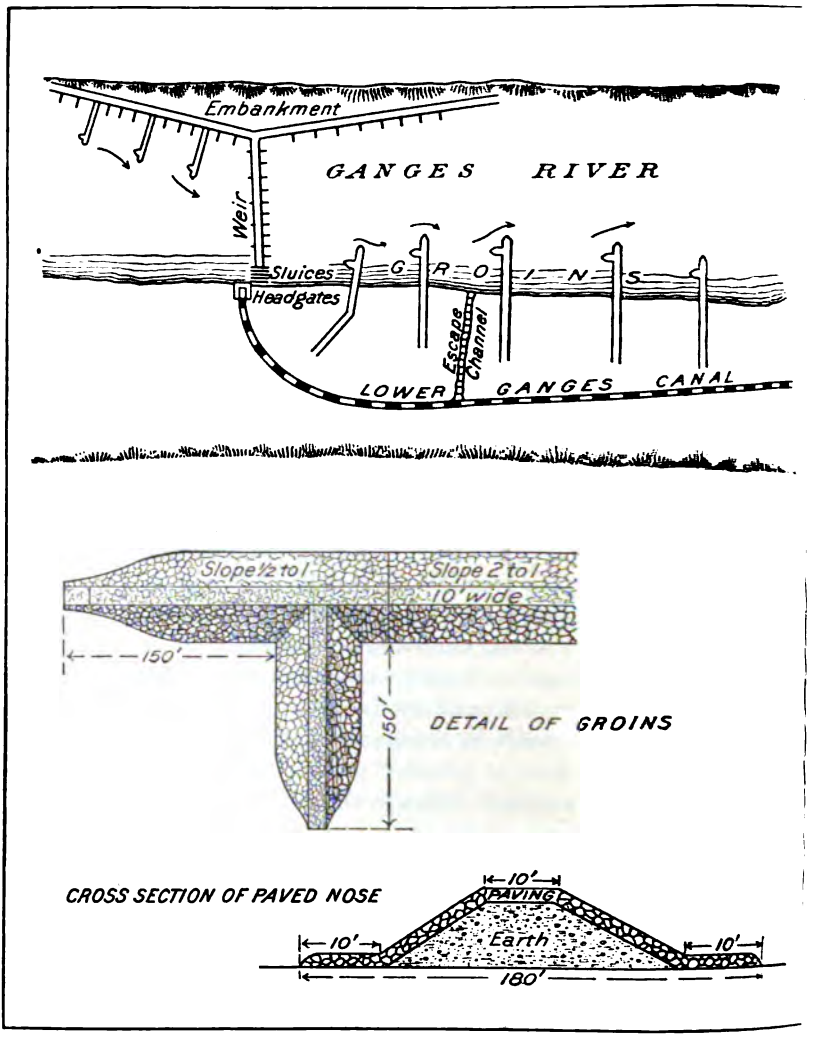


FIG. 65.—Training works, Lower Ganges canal, Narora.

destroying the canal itself below the weir. These training works extend 4 miles above the head of the canal and about 15 miles below it (fig. 65). The works consist on the upstream side of the weir of a long earthen embankment from which other embankments of earth jut out at right angles to the course of the stream, thus forcing

ırrent over to the other side. At first these embankments, or, as are called, "groins," were constructed so as to point downm, making an angle of perhaps 45° with the course of the curbut it was found that they did not work well. They have since realigned so that they project at right angles to the stream, and laced exactly one-half mile apart, and they are found to perform work excellently. As yet none have failed

ese groins are often very long, some as much as 2½ miles in h. They are simply straight embankments of earth 10 feet wide op, with slopes of 1 on 2. The last 150 feet at the end of the ı, or the nose, as it is called, is paved with heavy stones to a h of 2 to 3 feet, and at 50 feet from the end a spur 50 feet in length, larly paved, is run at right angles to the line of the bank, point-upstream.

t Hardwar, the head of the Ganges canal, the river runs between ı, steep gravel and rock banks, on which it is able to make no ression by erosion, and training works are therefore unnecessary ow the weir. Above it, however, the bed of the stream is so broad is divided into so many channels during the dry season that it is essary to construct extensive training works to keep open a pernent channel, known as the Hardwar Channel, which passes in front he head of the canal and supplies it with water. The fall of the er above the head-works is 8 feet per mile, and at low-water stage nas a velocity of 6 feet per second. This velocity is many times ater in periods of flood. As shown in the plan of the head-works Hardwar (fig. 18), the training works consist of bars sunk into the er channels to prevent the retrogression of grades and the conseent destruction of the dams; of weirs to turn the water into the ırdwar channel; of rectangular groins projecting into the river nilarly to those on the Lower Ganges canal, in order to keep the ıter in the Hardwar Channel; and, lastly, of embankments of bowlrs to protect the weaker portions of the river banks. Great difficulty ıs been encountered in maintaining the integrity of the noses of the oins, as the heavy floods undercut these and cause them to fall into ıe river. Great concrete blocks 3 by 5 by 2 feet in dimensions, weighıg 2 tons each, are first dropped into the river as a foundation for the roins. When these reach the water surface the end of the groin built up of loose concrete blocks in a regular manner, and the emainder of the groins, constructed of bowlders, is run back from his end. As the floods wash away the foundation blocks the built-up ortion of the groin falls in and replaces them, furnishing a new oundation, and this in turn is itself replaced. Thus in the course of few years the bed of the river becomes filled to such a depth with hese blocks that further destruction ceases to take place, and the groins will then stand for many years.

At the head of the Agra canal, at Okhla, the weir which diverts the

water into the canal head is, as before described, constructed of hand-placed rocks, and to preserve its integrity, and at the same time to train the course of the Jumna River toward its right bank and against the head of the canal, groins of a peculiar form of construction are run out at right angles to the line of the weir (fig. 66) and parallel to the course of the river. These works are known as "a

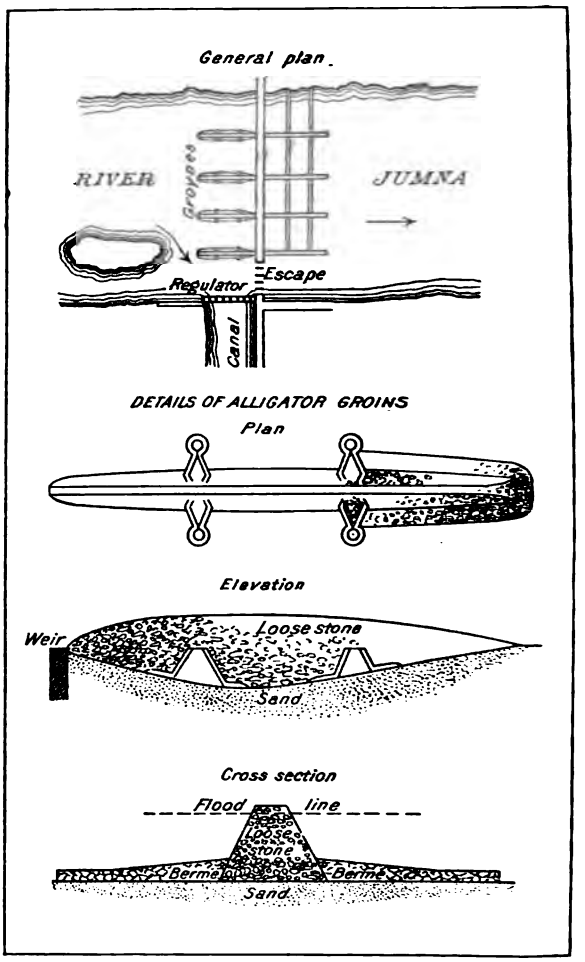


FIG. 66.—Training works, Agra canal, Okhla.

gator groins" from their peculiar form, which somewhat resembles that of an alligator. They are constructed of loose stones dumped into the river without any foundation on which to rest, the tops and sides of the groins being carefully hand laid, so as to give them shape and integrity. The floods annually wash away portions of these groins at first and during low season they have to be repaired, but like those on the Ganges canal, in the course of a few years the mass

'k underlying the groin becomes so great that repairs rapidly ıish in amount or entirely cease to be necessary. The tendency : water in the river is to flow in a direction nearly parallel to the ›f the weir and toward the under sluices, thus destroying the These groins cause portions of the water to flow over the weir ;ht angles to it, thus doing it no injury. Other portions of the m are forced over against an island, indicated in the accompany- late, and tend to remove it, at the same time furnishing a supply ıe canal head.

oonbills, or legs, are run out from the groins at right angles, and 'm 10 feet in width is built around the end of the groin and the nbill. The portion annually destroyed is the berm. This falls the river, leaving the main body of the groin intact. The top ıe groin is built at an elevation of 1 foot above highest flood l, and the top of the spoonbill is 7 feet below flood level.

LAND RECLAMATION.

good deal has been done in some of the more swampy portions of .a toward the reclamation of swamps and their conversion into valu- : agricultural properties. This reclamation has been most exten- ıly practiced in what are known as "duns," especially because it 'eases the healthfulness of these regions by substituting for marshes land under cultivation. Swamp reclamation has been practiced 'arious parts of the United States and the methods are essentially same in character as those employed for the same purpose in lia.

ı reclaiming marsh lands, such as those in the "duns," it has been ısidered usually essential first to make a complete survey of the ;ion in order to discover the slope of the lands in the direction in ıich cuttings for the purpose of drainage can best be made. The es on which the drainage cuts shall be made having been laid wn, it remains simply to so design these cuts that they shall com- ınd the gross area of the swamp in the most economical manner, and all completely remove the water from it. Some of these drainage ›rks have added thousands of acres of valuable land to the agri- ıltural regions, and have changed fever-stricken neighborhoods to 'althy cultivated fields where fevers are scarcely known. The finan- al returns from some of these works have been even greater and ore satisfactory than those from irrigation works proper, and recla- ıation works of this character are now prosecuted in India with as ıuch zest as is the construction of canals or storage works.

INDEX.

A. Page.

canal built by 89
Mount, altitude of 41
infall at 44
ption of water by soil, notes on 68-74
ge of irrigated land, statement showing 35-36, 57-58, 60
foot, definition of 67, 158
tanks, Arabia, description of 23
ate showing 22
rainfall at 44
canal, aqueduct over 23
urse of 95-96
ops under 96
rainage reservoir on 141-142
camination of 22-23
xpenses of 96
ead-works of 22, 95, 125, 130
istory of 95
Kushuk Falls on, cross section of 142
evenue derived from 58
raining works for 223-224
vater rate charged on lands under ... 96
vater supply of, source of 22
veir at head of 113, 120
cultural results of irrigation, statistics showing 58-62
ar, Emperor, irrigation works built by 47
Murdan, Delhi canal constructed by .. 47
Torrent, aqueduct at 23
arh, Ganges canal bifurcation at 92-93
rainfall at 44
nspection made at 19
nment of canals, considerations determining 107
ali, production of, by irrigation 64-66
removal of, by irrigation 64-65
ali Commission, report of, extracts from 65-66
ahabad, topography and agriculture near 16
visit to 18-19
ieen, duties of 52
itudes of Himalaya Mountains 39-41
erican irrigation compared with Indian, cost of works for each ... 60-62
derson, Colonel, cited on silt accumulation in canals 106
quoted on velocities of canals 106
icut. *See* Dam *and* Weir.
queducts, descriptions of 20, 23, 92, 138-144, 172, 218
plans and sections of . 139, 143, 144, 145, 149, 171
views of 102, 138, 140, 168
rabia, Aden tanks in, plate showing 22

Page.

Areas cultivated and irrigated, extent of 35, 57-60
Arrah canal, duty of water under 103
expenses of 103
size and course of 16, 102
Asafnagar Falls, Ganges canal, view of, plate showing 134
Ashti dam, description of 208-210
landslip at 212, 213
profile of 208
waterway of 210
Ashti tank, description of 208-210
data concerning 204
history of 206
Ashti tank and canals, map of 207
Assam, area, topography, and other features of 41
rainfall in 43, 44
tea cultivation in 37-38
Atgoan, trip to 14
Auckland, Lord, Ganges canal sanctioned by 90

B.

Bagge, Lieutenant, Betwa canal project investigated by 173
Baker, Maj. W. E., cited on serviceableness of Western Jumna canal. 32
report made by, on canal from Sutlej River 97
work on Ganges canal done by 90
Baker, Maj. W. E., and others of committee, cited on causes of sickness along Delhi canal 63
Baldwin, Latham, cited on circulation of water through soil 151-152
Bari Doab canal, area irrigated under ... 99
Chuki Torrent diversion on 137-138
cost of 99
cross section of, dimensions of 104
discharge of 99
duty of water along 72
falls on 135-136
head-works of, regulating sluices at .. 125
history of 99
rapids on 136
revenue derived from 99
sources of supply of 99
Barley, acreage and value of 60
season for growing 38
Baroda, tank on Surwa River above 23
Barrage du Nil, description of 82
examination of 24
Beale, H., aid by 13
Begari canal, data concerning 80

Page.

Belary, rainfall at 44
Beluchistan, irrigation project in 218–220
Bengal, area and population of 35
area cultivated and irrigated in 35
canals in 101–104
irrigation works in, data concerning 57
land tenures in 55
rainfall in 44
taxation or land rental in, mode of collecting 50
Beresford, J. S., cited on duty of water 67–72
cited on frictional resistance to sinking of masonry wells 132
Betwa canal, area served by 173
course of 173–174
cross section of, dimensions of 104
description of 173–181
diversion work on 138
duty of water along 73
head-works of, description of 175–176
plan showing 175
regulation gates at 127, 177
history of 173
regulator and scouring sluices of, plan of 177
Betwa reservoir, location and capacity of 19
Betwa River, discharge of 175
Betwa weir, description of 19, 176–181
plans and sections of 175, 176, 177, 178, 179
shutter gates of, plan and sections of 179
Bezwada, anicut at 83–84
Bhatgur dam, construction of, method of 188–189, 190
description of 13, 164–169
material used for 188–189, 190
mode of construction of 188–189, 190
plan and section of 165
statistics concerning 159
view of 164
Bhatgur reservoir, capacity of 164
cost of 172
location of, map showing 161
Bhore Ghauts, railroad through, route of 14
Biropa River, irrigation from 87
Blaine, Lieutenant, reference to 47
Block foundations, descriptions of 130–132
Boats, canal, description of 17, 18
Bombay, area cultivated and irrigated in 35, 57
duty of water in 67
irrigation works in, statistics concerning 57
land rental or taxation in, mode of collecting 50
land tenures in 55
laws relating to irrigation in 54
rainfall in 44
reservoirs or tanks in 204
temperature in 45
water rates in 57
water storage and distribution in 159, 204
Bonham, B. F., aid by 16
Brahmaputra River, source, course, and drainage area of 40
Brahmini River, irrigation from 86–87
Brandis, Dr., reference to 45
Brandreth, Colonel, aid by 22

Page.

British territory, area and population of ..... [illegible]
Brownlow, Major, cited on cost of maintaining distributaries ..... [illegible]
Buckle, Lieutenant, surveys for Nira Canal made by ..... [illegible]
Buckley, R. B., aid by ..... [illegible]
cited on cost of canals per acre of land served ..... [illegible]
cited on deltaic canals ..... [illegible]
cited on sluice gates of Soane canal at Dehree ..... [illegible]
cited on use of dunds or sotas as head-works for inundation canals ..... [illegible]
Budki Torrent, volume of ..... [illegible]
Burar weirs, data concerning ..... [illegible]
Burch, ——, and others of alkali commission, report of, extracts from ..... [illegible]
Burke, C. T., Ashti tank planned by ..... [illegible]
cited on Ashti dam ..... [illegible]
Burma, area cultivated and irrigated in ..... [illegible]
Buxar canal, course of ..... [illegible]
examination of ..... [illegible]
Byturni River, irrigation from ..... [illegible]

C.

Caird, James, and others, cited on value of irrigation works ..... [illegible]
Calcutta, researches made at ..... [illegible]
temperature at ..... [illegible]
Caldwell, Sir James, Periyar canal project considered by ..... [illegible]
Calicut, rainfall at ..... [illegible]
Caméré, M., aid by ..... [illegible]
Canal boats, description of ..... [illegible]
Canal regulators, descriptions of ..... [illegible]
Canals, alignment of, considerations determining ..... [illegible]
banks of, slopes of ..... [illegible]
beds of, slope of ..... [illegible]
classes of ..... [illegible]
cost of, per acre of land served ..... [illegible]
per cubic foot of capacity per mile ..... [illegible]
cross section of, determination of ..... [illegible]
cross sections of, figures showing ..... [illegible]
essential parts of ..... [illegible]
expenses of ..... [illegible]
head-works of, location of ..... [illegible]
health conditions along lines of ..... [illegible]
inundation, data concerning ..... [illegible]
irrigation, revenue derived from ..... [illegible]
machinery of, description of ..... [illegible]
mileage of ..... [illegible]
navigable, mileage of ..... [illegible]
perennial, data concerning ..... [illegible]
regulating gates for ..... [illegible]
sections of, figures showing ..... [illegible]
sickness along line of ..... [illegible]
silt accumulation in, prevention of ..... [illegible]
slopes of banks of ..... [illegible]
surveys for, character of ..... [illegible]
injury to, act prescribing penalties for ..... [illegible]
velocities of, discussion of ..... [illegible]
Carnatic, rainfall in ..... [illegible]
Carswell, E. A., aid by ..... [illegible]

Page.
ıtley, Sir P. T., cited on duty of water along Delhi and Doab canals 67
cited on health conditions along Delhi canal 63
Ganges canal line projected by 90
irrigation works constructed by 48
quoted on distributaries of Ganges canal 144
quoted on use of escapes 132, 133-134
quoted on value of irrigation 90
uvery canals, data concerning 85-86, 87
uvery River, data concerning 41, 42
weir on 109
vour canal, Italy, examination of 24, 25
wnpur branch of Ganges canal, course of 92-93
ment, sources of 189
ntral Provinces, area cultivated and irrigated in 35
ıara Punji, rainfall at 44
ıattaparu outlet of East Tamileru River, construction of 85
ıeela Bura tank, data concerning 201
ıembrambaukam tank, data concerning 204
ıenab canal, data concerning 81, 100
hardy River, reservoir or tank on 199
houting River, old canal deriving water from 47
huki Torrent, Bari Doab canal, diversion of 137-138
igliano canal, Italy, examination of 24-25
ivil engineers, recruitment of 51
lerke, W., aid by 11
cited on effect of strains and settlement of dams 188
reference to 14
ochin, temperature at 44-45
ockhorn, Mr., aid by 20
ocoanuts, production of 37
oimbatore, irrigation in, by wells 75
offee, production of 37
ollection of taxes or land rentals, methods of 49, 50, 52, 55
olvin, Col. John M., canal project of 90
reference to 48
oncrete, method of preparing 190, 191
onduitt, H. W., aid by 18-19
ost of irrigation works, statistics showing 9, 32-34, 57, 58, 99, 172
ost of material and labor, statements concerning 193-196
otton, acreage and value of 10, 36, 60, 96
season for growing 38
yield of, per acre 36
otton, Sir Arthur, Ganges canal defects reported by 90-91
Lower Ganges canal suggested by 93
reference to 84, 101
raig, James, cited on maximum flood discharge from catchment areas 157
rofton, Colonel, aid by 22
cited on time required after completion to make irrigation works profitable 33
cited on velocities in Ganges canal 106

Page.
rops, character of 96
double, notes on 66
extent and character of, table showing 36
method of irrigating 151
rotation of 38
irrigated, character and value of 60, 205
ross section of canals, determination of 104
ruikshank, Colonel, reference to 12
ultivated land in India, acreage of 35, 57-60
unningham, H. S., and others, cited on value of irrigation works 33-34

D.

ams, descriptions of 13, 14, 15, 19, 20, 22, 82-86, 94, 95, 109-119, 120-124, 175-176, 183-184, 188-193, 198-199, 205, 207-215, 217
earthen, slopes of 198
foundations of 155
materials used for 188-189, 190
masonry, designs and construction of 188-193
plans and sections of 109, 112, 114, 115, 116, 118, 121, 122, 123, 126, 165, 167, 170, 176, 182, 183, 186, 187, 192, 198, 208, 213, 216
profiles and sections of 198, 208, 213, 216
sites for, selection of 155-156
slopes of 198
temporary, details of 118-119
tops of, width of 198, 209
views of 84, 114, 116, 120, 122, 164, 168, 170, 182, 186, 188, 216
avidson, Prof. George, quoted on proper location of head-works for canals 108
ebude, Captain, irrigation works planned by 48, 89
eccan, topographic and geologic features of 41
ehree, head-works of Soane canal at 102
researches at 17
Soane River at, discharge of 103
weir at head of Soane canals at 121-122
elhi, astronomical observatories at 23
temperature at 45
elhi canal, construction of 47
duty of water along 67
sickness along, causes of 63
eltaic canals, discussion of 81-87
empster, J., reference to 21
empster, T. E., and others of committee cited on causes of sickness along Delhi canal 63
era Ismail Khan, rainfall at 44
esert canal, data concerning 80
ewatan tank, data concerning 201
hanowri, examinations made at 21
ickens, General, cited on revenue derived from irrigation works in India 32
Soane canal scheme proposed by 73, 101
ickens's formula for flood discharge from catchment basin, statement of 156
coefficients for 157
istributaries, arrangement of 154
descriptions of 144-150

Page.

Distributaries, heads of, location and features of 146, 148
losses of water in, by percolation 71
masonry outlet for, plan and section showing 156
mileage of 58, 59
Distributing head, Mutha canal, plans of. 148
Ditches. *See* Distributaries.
Dixon, Colonel, cited on results of construction of Mairwara tank embankments 201
irrigation works constructed by. 200, 201, 202
Doab Canal, duty of water along 67
Dora Baltea River, Italy, aqueduct across, examination of 24
Double cropping, notes on 66
Douleshwaram, irrigation works at 83
Drainage works, description of 137–144
Dredges, Soane canals, use of 18
Duhlia, rainfall in 44
Dunds, use of, as head-works for inundation canals 78–79
Duns, canals in, revenue derived from .. 96–97
crops grown in 97
irrigation in 97
location of 40
reclamation of 225
Duty of water, Arrah canal 103
Bari Doab canal 72
Bombay 67
data concerning 67–74
definition of 67
Ganges canal 93
Lower Ganges canal 95
measurement of, unit for 158
Sidhnai canal 100
Sirhind canal 99
Soane canals 103
Duvur tank, work at 85
Dyer, Colonel, cited on silt déposition in Western Jumna canal 106–107

E.

East India Company, irrigation works constructed by 48
Eastern Jumna canal, construction of ... 47
head-works of 99
irrigated area under 73
revenue derived from 58
Ekruk dam, landslip at 212–213
Ekruk tank, crops irrigated from 205
data concerning 204
description of 205–206
irrigation from, crops raised by 205
plan and sections of 204
Ellenborough, Lord, reference to 90
Engineering work, organization and administration of 51
Engineers, recruitment of 51
Escapes, descriptions of 132–134
Etawah, branch of Ganges canal, course of 92–93
Evaporation, data concerning 69, 73
diagrams illustrating 69
Everest, Mount, elevation of 39
Excavation, cost of 195–196
Expenditures on irrigation works, statistics concerning 9, 57–58

F.

Falls and rapids, discussion of ..... [illegible]
views of ..... [illegible]
Famine Commission (Indian), report extracts from ..... [illegible]
Farini canal, Italy, reference to ..... [illegible]
Farms or fields irrigated, sizes of ..... [illegible]
Feroze, Emperor, irrigation works under ..... [illegible]
Fertilizer, use of ..... [illegible]
Fields irrigated, sizes of ..... [illegible]
Fife, Colonel, cited on landslip at Ekruk dam ..... [illegible]
Mutha canal scheme proposed by ..... [illegible]
Nira canal project promoted by ..... [illegible]
Fife, Lake, dam at, description of ..... [illegible]
description of ..... [illegible]
statistics concerning ..... [illegible]
Financial results of irrigation, statistics showing ..... [illegible]
Floats for stream gauging, use of ..... [illegible]
Floods in rivers, precautions against ..... [illegible]
Fodder crops, acreage and value of, in 1901 ..... [illegible]
Forest reservations, area of ..... [illegible]
Forests, effect of removal of ..... [illegible]
preservation of, work done for ..... [illegible]
revenue derived from ..... [illegible]
Forrest, James, aid by ..... [illegible]
Foundations for masonry work, description of ..... [illegible]
Fruits, production of ..... [illegible]
Fuleli canal, data concerning ..... [illegible]

G.

Gadanamathi River, discharge of ..... [illegible]
Galton, Douglas, cited on effects of irrigation on health in India ..... [illegible]
Ganges canal, aqueducts along ..... [illegible]
Asafnagar Falls on, description of ..... [illegible]
view of ..... [illegible]
cost of ..... [illegible]
crops irrigated from ..... [illegible]
defects of ..... [illegible]
discharge of ..... [illegible]
dimensions of ..... [illegible]
distributaries of, mileage of ..... [illegible]
duty of water along ..... [illegible]
expenses of ..... [illegible]
Gopalpur bifurcation of, plate showing ..... [illegible]
head-works, description of ..... [illegible]
figure showing ..... [illegible]
plan of ..... [illegible]
regulating works at ..... [illegible]
health conditions along, provisions concerning ..... [illegible]
history of ..... [illegible]
land irrigable and irrigated from ..... [illegible]
Nadrai aqueduct on, figures showing construction of ..... [illegible]
ogee falls on ..... [illegible]
plans of ..... [illegible]
profile of, Hardwar to Roorkee ..... [illegible]
regulating gates of, figure showing ..... [illegible]
revenue derived from ..... [illegible]

Page.

ges canal, Rutmoo level crossing on, description of 142-143
view of 149
slope of 106
Solani aqueduct on 139
views on, plates showing 92, 120, 134, 142
water supplied by, amount of 93
weir at head of 116-117, 121
ges canal, Lower. *See* Lower Ganges canal.
r canal, data concerning 80
ges River, area drained by and course of 40
breadth, fall, and discharge of 42
dams (temporary) on 118-119
discharge of 66, 94
navigation on, as affected by irrigation 66
weir at Hardwar on 116-117
ngetan Plain, features of 16, 40
tes in dams, descriptions and figures of 83, 116, 119-130, 162, 165, 166-169, 177, 178-181, 185
ology of India, general features of 42-43
auts, features of 41, 43
western, rainfall in 44
a, temperature at 44-45
dahallow aqueduct, description of 218
davari canal, data concerning 87
davari River, breadth, fall, and discharge of 42
canal system in delta of 83
source, drainage basin, and deltas of .. 41
ohana tank, data concerning 201
ood, W., cited on Kali Nadi aqueduct ... 140
opalpur bifurcation, Ganges canal, plate showing 92
ordon, W. B., cited on well sinking for masonry foundations 132
overnor-general of India, powers vested in 49
rains, lands suitable for growing 38
reathed, Colonel, Betwa canal project examined by 173
opinion of, concerning weir for Betwa canal .....
roins of training works, descriptions of 221-222
figures showing 222, 223
Gulleri River, irrigation from 217

H.

Haig, F. T., cited on revenue to be expected from the Soane canals .. 103
Hamipur branch of Betwa canal, description of 174
dimensions of 174
Harbinge, Lord, Ganges canal project aided by 90
Hardwar, Ganges River at, discharge of .. 92
Ganges River at, features of 92
training works above 222-224
inspection made at 21
weir at head of Ganges canal near . 116-117
Hastings, Marquis of, reference to 47
Head-works, descriptions of 82-86, 94, 95, 107-109, 120, 125, 175-176

Page.

Head-works, location of, considerations determining 88-89, 107-109
plans and views of .. 127, 168, 169, 175, 183, 207
See also Dams, Training works, Sluices, Weirs.
Health, conditions of, along Delhi canal, facts bearing on 63
Heywood, quoted on discharge of principal rivers 42
Hilgard, E. W., reference to 65
Hill, A., quoted on masonry construction of Bhatgar dam 190
quoted on scouring sluices 166
Hill, Col. H., mention of 200
Himalayas, altitudes of mountains and passes in 39-41
drainage of 39-42
foothills of, altitude and topography of 40
geology of 42-43
origin of name 39
rainfall in 44
Sierra Nevada compared with 39
Hindun River, dam projected across 89-90
diversion of 22
irrigation canal from 96
Holdings of land, statistics concerning .. 55

Home, Col. F. J., reference to 20
Betwa canal project investigated by . 173
cited on Mairwara tank embankments 202
Horn, Mr., reference to 17
Hughes, W. C., aid by 11
Hurron Torrent, siphon for, across Sirhind canal 98

I.

India, administration and legislation of irrigation works in 48-55
area of and area cultivated and irrigated in 9-10, 35, 57-60
climate of 7
crops in, value of 10
cultivated area in 9
geology of 42-43
irrigated area in 9-10, 35, 57-60
irrigation in, administration of 48-55
expenditures for 9
value and necessity of 29-34
works on (list) 25-28
irrigation works in, cost of, compared with probable cost of similar works in United States 60-62
legislation and administration of irrigation works in 48-55
map of 11
population of 9
railway travel in 15
topography of central part of 15
Indigo, acreage of, under cultivation . 36, 96, 96
duty of water for 73
irrigation of, from Agra canal 96
production of 37
Indus River, course and drainage area of 39-40, 80
flood level and discharge of 42, 80

Page.

Indus River Valley, inundation canals in . 78-81
precipitation in 31
Inglis, W. A., aid by 17
computations regarding Arrah canal made by 103
Inundation canals, cost of 80-81
data concerning 78-81
expenses of 80-81
revenue from 80, 81
Irrigable area, acreage of 57-58, 59
Irrigated area, acreage of 35-36, 57-58, 60
Irrigated crops, acreage, character and value of 36
Irrigated fields, sizes of 55
Irrigated lands, revenue derived from . 35, 58
Irrigation, agricultural results of 58, 62
development of, method of promoting 50
expenditures for 33-34, 58, 80
extent and character of 57-58
history of 50
laws relating to 52-54
objections to 63-66
time required for, per acre 73
value and necessity of 29-34
water required for, amount of, per unit of area 73
wells used for 75-77
works on, list of 25-28
Irrigation canals. *See* Canals.
Irrigation engineers, mode of recruitment of 51
Irrigation works, administration of 48-55
agricultural results of 58-62
area served and to be served by 58, 60
classes of 56-57
conditions governing construction of 157-158
cost of 9, 32-34, 48, 57-62, 80-81, 99, 172
durability of 195
expenses of 32-34, 57-62, 80-81, 96, 103
financial results of 33-34, 58-62
history of 47-48
income from 32-35, 58-62, 99
legislation concerning 52-54
officers engaged in administration of . 51
value of, statistics showing 33-34
two classes of, productive and protective 29-30
Italy, irrigation canals in, examination of . 24-25
Ivrea canal, Italy, examination of 24, 25

J.

Jamrao canal, data concerning 80
Janamalli anicut, description of 217
Jehan, Shah, canals constructed under ... 47, 99
Jewhar Torrent, siphon for, beneath Nira canal, plan and sections of 171
Jeypur, astronomical observatories at 23
rainfall at 44
Jhelum canal, data concerning 81
Jumna canal, Eastern, construction of ... 47
head-works of 99
irrigated area under 73
revenue derived from 32, 58
value of 31-32

Page.

Jumna canal, Western, cost of ..... [illegible]
crops raised under in 1838, value of [illegible]
cross section of, dimensions of [illegible]
expenses of ..... [illegible]
first construction of ..... [illegible]
head-works of ..... [illegible]
irrigated area under ..... [illegible]
revenue derived from ..... [illegible]
silt deposition in ..... [illegible]
Jumna canals, earliest one constructed [illegible]
head-works of ..... [illegible]
regulating gates at ..... [illegible]
property saved by, value of ..... [illegible]
Jumna River, old canal deriving water from ..... [illegible]
irrigation canals from ..... [illegible]
training works on, description of [illegible]
figure showing ..... [illegible]
Jute, production and export of ..... [illegible]
Juwaja tank, data concerning ..... [illegible]

K.

Kabra tank, data concerning ..... [illegible]
Kalee Kuncur tank, data concerning [illegible]
Kali Nadi, aqueduct for Lower Ganges canal over ..... 30, 131-132, [illegible]
canal taken from ..... [illegible]
Kanigiri reservoir, escape from, plate showing ..... [illegible]
head sluices of, plate showing ..... [illegible]
work at ..... [illegible]
Kao Nulla siphon aqueduct beneath Soane canal, examination [illegible]
description of ..... [illegible]
figure showing ..... [illegible]
Kathund branch of Betwa canal, dimensions of ..... [illegible]
Khoord, dam site at ..... [illegible]
Khundwa, rainfall at ..... [illegible]
Khutowli escape, Ganges canal, features of ..... [illegible]
King, M., aid by ..... [illegible]
King, Dr. W., aid by ..... [illegible]
Kistna anicut, river in moderate flood, plate showing ..... [illegible]
Kistna canal, data concerning ..... [illegible]
Kistna River, breadth, fall, and discharge of ..... [illegible]
canal system in delta of ..... [illegible]
source, drainage basin, and delta of [illegible]
Kolevoy tank, features of ..... [illegible]
Kurnool canal, data concerning ..... [illegible]
Kurra aqueduct, Nira canal, view of ..... [illegible]
Kurra River, aqueduct for Nira canal over ..... [illegible]
Kushuk Falls, Agra canal, cross section of [illegible]

L.

Labor and material, cost of ..... [illegible]
Lahore, trip to ..... [illegible]
Lake, Sir Atwell, reference to ..... [illegible]
Land irrigated, acreage of ..... [illegible]
Land reclamation, method of ..... [illegible]
Land rentals, collection of, method of [illegible]

Page.
d tenures, statistics concerning .. 55
dslips at dams, instances of 212 214
use of, for lifting water 75
ham, Baldwin, reference to 14
s concerning irrigation, quotations from 52-54
Quesne, W. H., reference to 13
islation concerning irrigation works, features of 52-54
inge, H. C., head-works of Soane canal, designed by 103
sanee weir, data concerning 201
ver Ganges canal, aqueduct for, over Kali Nadi 139-140
aqueducts over 20, 131
area irrigable and irrigated from 94-95
cost of 94
course of 94
discharge of 94
duty of water under 95
expenses of 95
head-works and river-training system of 20, 94
head-works of, foundations for 130-131
regulating gates at 128
history of 93-94
Nadrai aqueduct of 131
Narora weir of 20, 112-113, 119-120, 126
revenue derived from 58, 94
silting in, absence of 125
training works on, description of 221-222
figure showing 222
weir at Narora on .. 20, 112-113, 119-120, 126

M.

Iachka Torrent, plan and section at 219
Iadag Masur tank, description of 199
Iadras, area and population of 35
area cultivated and irrigated in 35, 57
assessment rates on irrigated and non-irrigated land in 32
deltaic canals in 83-85
irrigation works in, area served by .. 57
cost of 57
description of 181-187
location of 57
revenue derived from 57
land tenures in 55
rainfall in 44
tanks in 202, 203-204
temperatures in 44
Madras Irrigation Company, construction of works by 48
Madwa Rou, mention of 109
Mahanadi canal, headworks of 217
length of 217
Mahanadi River, irrigation from 86-87, 217
features of 82
Mahanadi weir, sluices in, features of .. 120-121
Mairwari tank embankments, cost of 201
data concerning 201-202
irrigation from 201
results of construction of 201-202
dimensions of 201
Maize, acreage and value of, 1900-1901 60
Manalore, rainfall at 44

Page.
Manure, use of 38
Maps of India, character of 155
Marsh lands, reclamation of 225
Masonry, cost of 31, 196
durability of 195
Masonry dams, designs and construction of 188-193
Materials used in construction of irrigation works, cost of 196
McNeill, Col. J. M., aid by 16
Medley, Col. J. G., cited on sluiceways of Mahannudy weir 121
Medlicott, H. B., and others of alkali commission, report of, extracts from 65-66
Merriman, Col. C. J., Ashti tank plans prepared under orders of 206-207
Meteorology, features of 43-45
Mhaswad tank, data concerning 204
Midnapore canal, Bengal, data concerning 86-87
Millet, acreage and value of 60
lands suitable for growing 37, 38
Misau, weirs at 109
Mogul canals, construction of 47
restoration of 48
Molesworth, G. L., cited on designs for masonry dams 191
Molesworth's formula for profile of masonry dams 191, 192
Moncrieff, Col. Sir Scott, aid by 24
Mooltan, rainfall at 44
temperature at 45
Mortality, rate of 35
Mortar, method of preparing 189-190
tests of 190-191
Mount. *See next word in name.*
Mot, figure and plate showing 74, 77
use of, for lifting water 75
Muddur weir, cross section of 109, 110
Mullins, Gen. J., cited on conditions to be considered in undertaking the construction of irrigation works 157
cited on dimensions of dams 211-212
formula of, for profile for masonry dams 192
Mutha canals, bridges and head-gates of, construction of 13
city of Poona supplied by water from. 58
cost of 159
distributaries on, plans of heads of 148
duty of water along 67
head of 12
history of 160
inspection of 12-13
map showing location of 161
municipal service of water by 58
revenues derived from 160
sickness along, causes of 64
statistics concerning 159, 160
Mutha irrigation project, description of 160-163
map showing 161
Mutha River, course of, map showing 161
source of 160

Page

Mutha River Valley, topography, soil, and agriculture of ... 12
Muthra, rainfall at ... 44
Muzaffargarh canal, data concerning ... 81
Myapur, headworks of Ganges canal at ... 119, 125-126
weir at ... 22, 92, 120
gates in ... 120
sluices in ... 120
Mysore, tanks in ... 202-203

N.

Nadrai aqueduct, foundations of ... 131
foundation wells for, view of ... 130
history of ... 139-140
sections of ... 145
Nanel grass, planting of, to reclaim riparian land ... 221
Narora, headworks on Lower Ganges canal at ... 120, 131
researches made at ... 19-20
training works at ... 222
weir at, features of ... 94, 112-113, 119, 126
material used for ... 189
plans of ... 116, 120
Nasregunge, researches at ... 16-17
Navigation of tapped rivers, effect of irrigation on ... 66
Navigation on irrigation canals, difficulties of ... 195
Negar, rainfall at ... 44
Nile River, irrigation works in delta of ... 82
Nira canal, catchment basin for ... 164
cost of ... 172
cross section of, dimensions of ... 104
figure showing ... 170
expenses of ... 160
head-works of, description of ... 169-171
plans and section of ... 169-170
regulating gates at ... 128
history of ... 163-164
irrigation from, time required for ... 73
location of, map showing ... 161
regulator head on, plan of ... 170
superpassage of, at siphon for Jewhar Torrent ... 171, 172
weir at head of, cross section of ... 170
Nira canal system, cost of ... 159, 172
description of ... 163-173
map showing ... 161
revenues derived from ... 173
source of water for ... 13
statistics concerning ... 159, 160
views showing works of ... 164, 168, 170
Nira River, map showing course of ... 161
Northwest Provinces, area cultivated and irrigated in ... 35
canals in ... 89-97
irrigation by wells in ... 75
area served by ... 58
cost of ... 58
extent and character of ... 58
revenue derived from ... 58
rivers of, discharge of ... 88
Nundyal tank, features of ... 200

O.

Ogee falls, use of ... [illegible]
Oil seeds, production and use of ... [illegible]
Okhla, Agra canal head-works at ... [illegible]
examinations made at ... [illegible]
training works at, description of ... [illegible]
plans and sections of ... [illegible]
weir at, sluices in ... [illegible]
Orai, visit to ... [illegible]
Oreste, Canavotte, aid by ... [illegible]
Orissa canals, cost of, per acre of land served ... [illegible]
data concerning ... [illegible]
weir at head of, sluices in ... [illegible]
Ottley, Major, reference to ... [illegible]
Oudh, area cultivated and irrigated in ... [illegible]
irrigation works in, cost of ... [illegible]
extent of ... [illegible]
revenue derived from ... [illegible]

P.

Paecottah, figure and plate showing ... [illegible]
use of, for lifting water ... [illegible]
Palar anicut system, data concerning ... [illegible]
description of ... [illegible]
map showing ... [illegible]
plan and cross section of ... [illegible]
weir of ... [illegible]
Palmer, C. G., aid by ... [illegible]
Palmer, E. C., cited on duty of water of Bari Doab canal ... [illegible]
Parasnath, Mount, altitude of ... [illegible]
Paricha, Betwa canal head at ... [illegible]
Patna, rainfall at ... [illegible]
Patna canal, course of ... [illegible]
Patrala Sombe, masonry dams at ... [illegible]
struction of ... [illegible]
Pattiala, Maharajah of, mention ... [illegible]
connection with canal from Sutlej River ... [illegible]
Pease, irrigation of, from Agra canal ... [illegible]
Peile, J. P., and others, cited on value of irrigation works ... [illegible]
Penner Canal, data concerning ... [illegible]
Penner River delta, irrigation works in ... [illegible]
Penny, Capt. C. B., Ashti tank projected by ... [illegible]
Pennycuick, Major, cited on formula for profile of masonry dams ... [illegible]
report on Periyar canal project made by ... [illegible]
Peranny River, weir on ... [illegible]
Percolation, diagrams illustrating ... [illegible]
losses by ... [illegible]
observations on ... [illegible]
Perennial canals, data concerning ... [illegible]
Periyar project, dam for, material used in construction of ... [illegible]
dam for, section of ... [illegible]
view showing ... [illegible]
description of ... [illegible]
head-works for, plan of ... [illegible]
plan of ... [illegible]
reservoir for, capacity of ... [illegible]
Persian wheel, figure and plate showing use of, for lifting water ... [illegible]

Page.
nts in canal beds, prevention of growth of ... 105
River, Italy, weir across ... 24
na, labor prices at ... 195
storage reservoir near ... 160
tunnel for Mutha canal at ... 163
water supplied to, by Mutha canal. 58
rniah weir, mention of ... 109
py (for opium) production of ... 37
ulation of India, by provinces, table showing ... 35
total ... 9
ter, Hon. A. G., aid by ... 24
atoes, production of ... 37
cipitation. *See* Rainfall.
vinces of India, area and population of, table showing ... 35
lse, acreage and value of, 1900-1901 ... 60
niary tank, dam of ... 199
njab, area and population of ... 35
area cultivated and irrigated in ... 35, 58, 73
canals in ... 78-81, 97-101
irrigation by wells in ... 75
area served by ... 58, 73
cost of ... 33, 58
extent of ... 58
revenue derived from ... 58
land rental or taxation in ... 50
land tenures in ... 55
rainfall in ... 43, 44
revenue from irrigation works in ... 34
rivers of, discharge of ... 88
topography of ... 89
wheat production in ... 36-37
uthri Torrent, aqueduct over Ganges canal for ... 21, 92, 140-141

R.

ailway travel in India, features of ... 15
ainfall, amount and distribution of ... 43-44
anipur Torrent, aqueduct over Ganges canal for ... 21, 92, 140-141
apids and falls, discussion of ... 134-136
avi River, irrigation canals from ... 99, 100
section of, at dam for Sidhnai canal ... 117
eay, Lord, reference to ... 14
ebsch, Mr., aid by ... 12
eh Commission, report of, extracts from ... 65-66
Reid, H. S., and others of alkali commission, report of, extract from 65-66
Reinold, E. K., weir gate devised by, description of ... 166-169
weir gate devised by, plans and sections of ... 166, 167, 168
Reservoirs, descriptions of ... 19, 153-220
Revenue from irrigation works, amount of ... 58
mode of collecting ... 49-50
statistics concerning ... 32-34, 35, 57-58
Rice, acreage of ... 36, 37, 93
irrigation of, methods employed for ... 151
lands used for production of ... 37
season for growing ... 38
yield of, per acre ... 37
River conservancy, methods of ... 221-225
River flow, rate of, mode of determining. 74
Rivers, breadth, fall, and discharge of, table showing ... 42
navigation of, as affected by water draft for irrigation ... 66
River training, methods of ... 220-224
Riverside lands, reclamation of, by planting of Nanel grass ... 221
Road crossings over canals, bridges at, form of ... 17
Roopana weir, data concerning ... 201
Roorkee, aqueduct near ... 92, 139
examinations made at ... 21, 22
Retto canal, Italy, reference to ... 24
Rundall, Colonel, reference to ... 101
Reinold, E. K., weir gate devised by. 166-167, 168
Rupar, head-works of Sirhind canal near 98
Rushikulya project, description of ... 217-218
Russell, Scott, cited on slope of dams ... 210
Russellkonda dam, view of ... 216
Russellkonda head sluice, view of ... 216
Russellkonda tank, description of ... 217-218
Rutmoo Torrent, junction of, with Ganges canal ... 21, 92, 142-143
view showing ... 142
Ryatwari, land tenures of ... 55
Ryves, Major, report made by, on Periyar canal project ... 182
Ryves's formula for flood discharge from catchment basin, statement of, and coefficient for ... 156, 157

S.

Saharanpur division of Eastern Jamna canal, irrigated area in ... 73
Sakkur, flood discharge of Indus River above ... 42
Saluggia, Italy, canals near, examination of ... 24-25
Sangam anicut project, description of ... 85-86
Sankey, Maj. R. H., cited on mode of construction of old (native) head-works of canals ... 110
cited on use of tanks in Mysore ... 202-203
Santhia, Italy, irrigation works near, examination of ... 25
Sasoon superpassage over Sirhind canal, description of ... 141
plan and section of ... 149
Schuyler, Eugene, aid by ... 24
Scouring sluices, description of ... 119-124
Second-foot of water, definition of ... 67
irrigating power of ... 73
Sewalik Hills, geology of ... 42
Shadouf, use of, for lifting water ... 75
Shutter gates in dams, descriptions and figures of ... 83, 116, 119-130, 162, 165, 166-169, 177, 178-181, 185
Sickness along Delhi canal, causes of ... 63
Sidhnai canal, area irrigable under ... 100
character of ... 97
cost of ... 101
course of ... 100
crops irrigated from ... 100
discharge of ... 101
duty of water under ... 100

Page.
Sidhnai canal, head-works of ... 100-101
head-works of, regulating gates at 129-130
history of ... 97, 100
revenue derived from ... 59, 101
section of river in line of dam on ... 117
water rate under ... 101
weir at head of, plans and section of ... 116
Sidhnai weir, plan and section of ... 116
sluice gates of, features of ... 123, 124
figure showing form of ... 123
Sierra Nevada, comparison of Himalayas with ... 39
Silt, deposition of, in canals, prevention of ... 105, 106
Simla, temperature at ... 45
Sind, area cultivated and irrigated in ... 31, 35, 57
inundation canals in ... 78-81
irrigation in, cost of ... 57
irrigation works in, cost of ... 57
revenue derived from ... 31, 35, 57
rainfall in ... 31, 43, 44, 98
Sirhind canal, aqueducts along ... 98
area irrigable and irrigated by ... 61, 98
cost of ... 61, 99
course of ... 98
crops irrigated from, acreage and value of ... 60
cross section of, dimensions of ... 104
discharge of ... 98
duty of water under ... 99
head-works of ... 98
history of ... 97-98
length of ... 98, 99
map showing ... 98
revenue from ... 99
Sasoon superpassage over, description of ... 141
plan and section of ... 149
torrents crossing ... 98, 141, 149
water rate under ... 99
Siswan Torrent, volume of ... 98
Skipworth, Col. G. T., reference to ... 18, 21
Slope of banks and beds of canals, data concerning ... 104-107
Sluiceways, features of ... 119-130
Sluices, scouring, description of ... 119-124
plan of ... 177
Smith, Col. R. Baird, cited on dimensions of Mairwari tank, embankments, and piers ... 200
cited on time required after completion to make irrigation works profitable ... 33
cited on value of Eastern Jumna canal ... 31-32
quoted on effect of irrigation on the navigation of tapped rivers ... 66
quoted on mode of construction of weirs ... 111
report made by, on projected course of Sirhind canal ... 97
Periyar canal project submitted by ... 182, 183
Soane canals, aqueducts along ... 102, 138-139, 143-144
area irrigated from ... 103
boats on, description of ... 17-18
Soane canals, cost of ...
cross section of main western branch of ...
distributaries along, surplus ...
dredges used on ...
duty of water under ...
examination of ...
expenses of ...
falls on ...
head-works of, description of ...
foundation wells at ...
gates at ... 125, 127
history of ...
inspection of ...
Kao Nulla siphon aqueduct between main western branch of ...
length of ...
locks of ...
map showing courses of ...
passenger traffic on ...
revenue derived from ...
traffic on ...
trees on banks of ...
velocity of flow of water in ...
water rate under ...
weir at head of, description of ...
plan of ...
shutter on, figure showing form of ...
sluices of, figure showing ...
features of ...
sluiceways in ...
Soane River, canals taking water from ...
course of ...
discharge of ...
weir across ...
Soil, absorption of water by, notes on ...
circulation of water in, experiments made to show ...
composition of ...
fertility of ...
Solani aqueduct, examination of foundations for ...
cross section of ...
description of ...
view of, plate showing ...
Sone canals. See Soane.
Soorooly River, utilization of, for irrigation purposes ...
Sorghum, production of ...
Sospizio, Carlos, aid by ...
Sotas, definition of term ...
use of, as head-works for inundation canals ...
Spices, production of ...
States, native, area and population of ...
Stevenson's formula, statement of ...
Stoney free-roller gate at tunnel head, description of ...
Storage of water, cost of ...
Storage works, descriptions of ...
Strachey, Gen. Richard, Betwa canal proposed by ...
cited on time required after completion to make irrigation works profitable ...

Page.
hey, Gen. Richard, Ganges canal defects reported by 91, 93
hey, Gen. Richard, and others, cited on value of irrigation works .. 33-34
m velocity, mode of gaging 74
' cane, acreage and value of ... 36, 37, 60, 93
ity of water for 67, 73
rigation of, methods employed for .. 151
ason and district for growing 37, 38
ur canal, data concerning 80
ran, H. E., and others, cited on value of irrigation works 33-34
la Reservoir, location of 217
eys for canal lines, character of 89
'a River, tank on 23
j canals, data concerning 81
j River, irrigation canal taken from 97-98
up lands, reclamation of 225

T.

il, administration of 49
ilerru River, east branch of, canal from 85
ks, dams of 198, 205, 206, 207-209, 211-214
ks for water storage, descriptions of 153-220
sa dam and reservoir, description of 14-15, 187-188
cost of 188
views and sections of 186, 188
ai, features of 40
il, regulations concerning 51, 149-150
es or land rentals, mode of collecting 49, 50, 52, 55
, cultivation of 36, 37-38
nperature, notes on 43, 44-45
nple, Sir Robert, cited on tanks in Mysore 202
eft of water, penalty for 53
onnason College of Civil Engineering, visit to 22
ora Nulla aqueduct, Soane canal, description of 17, 138-139
figure showing 102
ornton, W. T., cited on violent floods due to forest removal 46
uillier, Col. H. R., aid by 16
mber, sale of, income derived from 45
bacco, production of 36, 37
pography, features of 39-43
aining works for rivers, descriptions of 220-224
plans of 121
ees along canals, species of 18
emenheere, Col., cited on silt deposits in inundation canals 79
richinopoli, temperatures at 44
ulkad, old weir at 109
ullock, Maj. Hector, Tonsa reservoir project promoted by 187
uticorin, rainfall at 44
temperature at 44

U.

nited Provinces and Oudh, area and population of 35
United States, irrigation works in, cost of, compared with cost of works in India 60-62

V.

V weirs, condition favoring construction of 150
Vaigai River Valley, irrigation of, project for 181-187
Vanupshahr branch of Ganges canal, course of 93
Vedacunay channel, mention of 186
Veeranum tank, dam of 199
Vegetables, production of 37, 60
Velocities of canals, discussion of 105-106
Velocity of streams, mode of measuring 74
Viceroy of India, powers vested in 49
Vindhaya Mountains, drainage of 41
Vir, dam at, features of 13-14, 189
head-works of Nira canal at, description of 128, 169-171
view of 168
Vir River, view showing 170
Virainum tank, data concerning 204
Vonder Horst, W. P., aid by 19

W.

Wargaon River, aqueduct for Nira canal over 172
Water, circulation of, in soils 151-152
distribution of, rules and regulations for 51-52
duty of, data concerning 67-74
unit of measurement for 158
methods of applying 150-152
storage of, cost of 158
theft of, penalty for 53
Water rates or rents, act fixing 53
act regulating levying of 52
collection of, method of 49, 50, 52, 55
statements of 31, 57, 96
Weeds in canal beds, growth of, prevention of 105
Wegmann, Edward, cited on design and construction of masonry dams 191
Weir gate, plan and sections of 166, 167, 168
Weirs, descriptions of 13, 14, 15, 19, 20, 22, 82-86, 94, 95, 109-124, 175-176, 183-184, 188-193, 201, 205, 207-215
form and construction of 109-119, 188-193
formula for discharge over 103
open and closed, comparison of 110
plans and sections of 109, 112, 114, 115, 116, 118, 121, 122, 123, 126, 165, 167, 170, 175-179, 182, 183, 186, 187, 192, 198, 208, 213, 216
views of 84, 114, 116, 120, 122, 164, 168, 170, 182, 186, 188, 216
Well foundations, descriptions of 130-132
Wells, irrigation by 56, 75-77, 96
Western Jumna canal, cost of 99
crops raised under, in 1838, value of 32
cross section of, dimensions of 104
expenses of 99
first construction of 47
head-works of 99
irrigated area under 74
revenue derived from 99
silt deposition in 106-107

Page.
Wheat, acreage and value of 36, 60, 93, 98
cost of irrigating 73
duty of water for 67, 72
season for growing 38
yield of, per acre 36–37
Whiting, J. E., surveys for Nira canal made by 164
Williamson, Mr., aid by 17
Wilson, W. J., reference to 21
Winds, direction and character of 43
Works for irrigation, classes of 56–57

Y.

Yule, Lieut. H., and others, cited on cause of sickness along Delhi canal ..... [illegible]

Z.

Zabita Khan, reference to ..... [illegible]
Zemindars, functions of ..... [illegible]
land holdings of ..... [illegible]
Zhara Karez irrigation project, description of ..... [illegible]
map and section of ..... [illegible]
Zilahdars, duties of ..... [illegible]

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

HE PASSAIC FLOOD OF 1902

BY

GEORGE BUELL HOLLISTER
AND
MARSHALL ORA LEIGHTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

CONTENTS.

	Page.
ıtroduction	9
›escription of Passaic Basin	9
The Highland area	10
The central basin	11
The lower valley	13
ſributaries of the Passaic River	15
Saddle River	15
Ramapo River	15
Wanaque River	16
Pequanac River	16
Rockaway River	17
Whippany River	17
Upper Passaic River	17
Summary	18
Flow of Passaic River	19
The flood of 1902	30
Precipitation in the Passaic Valley	31
Gage heights	34
Flood flow of Highland tributaries	36
Flood flow at Little Falls	39
General flood-flow statistics in Highland tributaries	41
Submerged lands in central basin	42
Flood flow at Dundee dam	43
Flood below Dundee dam	44
Flood discharge of Saddle River	45
High-water marks in lower valley	46
Losses caused by the flood	48
Comparison with previous floods	51
Summary	52
Conclusions	53

ILLUSTRATIONS.

		Page.
ATE I.	*A*, Railroad bridge at Passaic Bridge; *B*, Passaic Falls at Paterson, showing gorge	9
II.	Drainage area of Passaic River	10
III.	Part of flooded area in central basin near Fairfield	12
IV.	*A*, Dam at Little Falls; *B*, Passaic Falls at Paterson	16
V.	*A*, Little Falls gorge at low water; *B*, Little Falls gorge at high water	20
VI.	*A*, Falls, Pompton Lake; *B*, Little Falls gorge, looking under Morris Canal viaduct, high water	24
VII.	*A*, Rockaway River at Boonton; *B*, Dam at Dundee	30
VIII.	*A*, Measurement station at Stanley on Passaic River; *B*, Measurement station at Whippany on Whippany River	34
IX.	*A*, Measurement station on Rockaway River near Boonton; *B*, Macopin dam	38
X.	*A*, Gaging station No. 1, on Wanaque River at Pompton; *B*, Gaging station No. 2, on Wanaque River at Pompton	42
XI.	Map of flooded area in central basin	In pocket.
XII.	*A*, Dam on Pequanac near Pompton; *B*, Submerged flat lands at Singac	44
XIII.	*A*, Flooded area on Great Pierce Meadows; *B*, Flood at Two Bridges	46
XIV.	*A*, Flooded farmhouse in central basin; *B*, Flooded farm lands in central basin	48
XV.	*A*, Wallington during the flood; *B*, Failure of bridge at Passaic	50
IG. 1.	Cross sections of Passaic Valley from Clifton to Newark	14
2.	Profile of Passaic River and tributaries	18
3.	Discharge of Passaic River at Two Bridges, 1902	28
4.	Discharge of Pompton River at Two Bridges, 1902	29
5.	Gage readings of Little Falls and Dundee dam	35
6.	Plan of Beattie's dam, Little Falls	36
7.	Flow curves at Little Falls	40
8.	Discharge curves at Little Falls and Highland tributaries	40
9.	Flood curve, Dundee dam	42
10.	Comparative flow curves, Dundee dam and Little Falls	43
11.	Profile of flood crest, Passaic to Belleville	47

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., March 30, 1903.

r: I have the honor to transmit herewith a manuscript by George ollister and Marshall O. Leighton, relating to a serious flood in Passaic River basin in northern New Jersey in February and ch, 1902, and recommend its publication in the series of Water-ply and Irrigation Papers.

he region affected by the flood, although a limited area, contains, roximately, one-third of the population of the entire State. Owing s proximity to the city of New York and to its natural advantages of -water frontage and water powers, it contains not only many attract-residential suburbs, but also important commercial and manufac-ng centers. The vested capital and community interests are large, it is therefore desirable that the occurrence and progress of at floods in the drainage area be thoroughly understood. This estigation into the most disastrous flood ever known in the Passaic lley is of timely interest to all classes of citizens dwelling on low-ds subject to floods.

Very respectfully,

F. H. NEWELL,
Hydrographer.

lon. CHARLES D. WALCOTT,
Director, United States Geological Survey.

A. RAILROAD BRIDGE AT PASSAIC BRIDGE.

B. PASSAIC FALLS AT PATERSON.

THE PASSAIC FLOOD OF 1902.

By G. B. HOLLISTER and M. O. LEIGHTON.

INTRODUCTION.

Late in February and early in March, 1902, there occured upon the rainage basin of the Passaic River in northeastern New Jersey the ıost disastrous flood in the history of the region. Not only was the ischarge the largest recorded, but the flood was the most destructive o life and property in the settlements ever known along the valley.

In the following pages it is proposed to outline the history of this lood, describe the conditions under which it occurred, give the estinated volume of its discharge, and indicate as well as possible the ıature and extent of the damage resulting from it.

The data and information embodied in the following report were ›btained by personal observation while the flood was in progress and ıfter it had subsided and from various water companies, manufacturers, and residents of the flooded areas. Acknowledgments are especially due to Mr. J. H. Cook, of Paterson, engineer for the Society for the Establishment of Useful Manufactures; to Mr. M. R. Sherred, engineer of the water department of the Newark board of public works; to Mr. R. M. Watson, of Wise & Watson, engineers of Passaic; to Mr. C. C. Vermeule, from whose valuable report on the water supply of New Jersey much data have been taken regarding the physical condition of the watersheds, and to others whose help or suggestions have been of value.

As the region under discussion, though comparatively restricted, is an important one owing to its dense population and rapidly increasing industrial development, and as the physical and physiographic conditions governing high-water stages on the Passaic watershed are peculiar, it is deemed necessary for a full understanding of the present flood to describe briefly their most important features.

DESCRIPTION OF PASSAIC BASIN.

The Passaic River is the most important stream in the State of New Jersey. Its drainage basin covers 949.1 square miles, about 818 of which are in the northeastern portion of the State of New Jersey, while

132 are in the State of New York. On or near its banks are located the cities of Paterson, Passaic, Newark, Orange, East Orange, and Jersey City, the population of which combined with that of adjacent towns and boroughs equals over 500,000, or about one-third the population of the State of New Jersey. The quantity of sewage discharged from this district, with its great population, centered in the lower part of the drainage area, is extraordinary, and the industries carried on in the different communities contribute enormous amounts of manfacturing refuse, all of which is turned into the stream. The results of this wholesale deposit of filth are that for the last 20 miles of its course the river presents one of the most aggravated cases of pollution to be found in the United States.[a]

The water powers of the Passaic were among the first used in the country. The Society for Establishing Useful Manufactures was formed in 1791, for the purpose of developing the large power existing at the Great Falls of the Passaic in the city of Paterson (Pl. I, B). Other powers of less extent are found and improved at Pompton, Boonton, Little Falls, Dundee, and elsewhere on the drainage area.

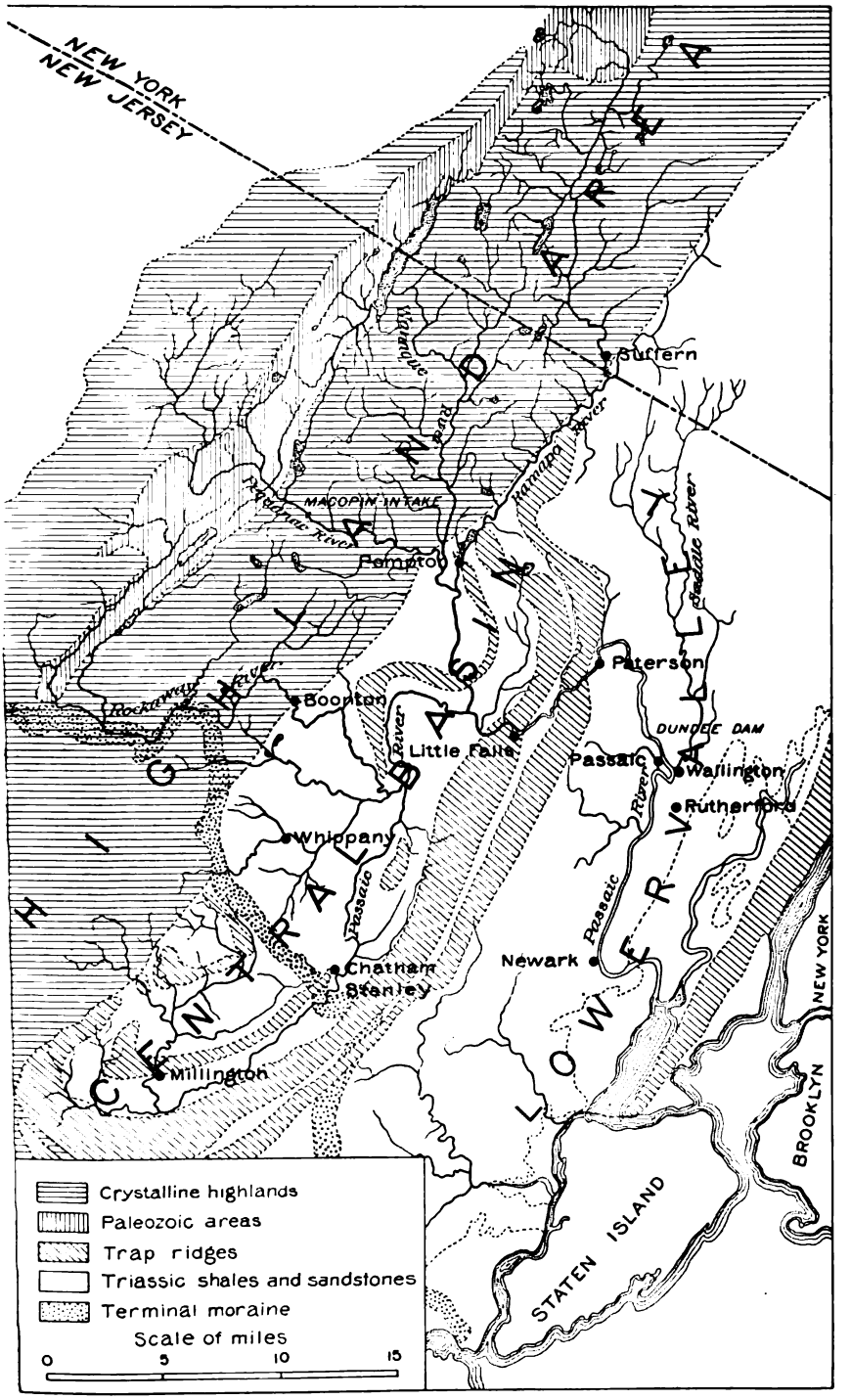
The water of the river is, however, of greatest value for municipal supply. It is already largely used for this purpose, and the demands of a rapidly growing population in the cities of northern New Jersey require that a proportionately greater amount shall be set aside from year to year.

The drainage area, as seen from Pl. II, falls naturally into three broad topographic divisions, viz, the Highland area, the central basin, and the lower valley.

THE HIGHLAND AREA.

The Highland area is the main gathering ground of the tributaries, whose united catchment basins cover 510 square miles or 53 per cent of the entire drainage area. It is a mountainous region composed of granitic and crytalline rocks which extend in a belt running northeasterly through northern New Jersey into New York State, with a width in New Jersey of from 15 to 20 miles. The region has a general altitude of from 1,000 to 1,500 feet above sea level, and represents the remnant of an old and much dissected plateau. Owing to intense metamorphism and folding of the rocks and to subsequent erosion, the highlands lie in ridges which follow a generally northeast-southwest trend. These ridges are transversely trenched by the the main arteries of the tributaries in steep-sided valleys whose bottoms lie from 300 to 600 feet below the crests. The most important tributaries which occupy this region are the Ramapo, Wanaque, Pequanac, Rockaway, Whippany, and a small portion of the upper waters of the Passaic proper. Upon it are also a number of lakes and artificial reservoirs, the latter built by water companies, which afford considerable storage.

[a] See Water-Supply and Irrigation Paper No. 72.



DRAINAGE AREA OF PASSAIC RIVER.

ch of the area has a covering of glacial drift, which is thick in localities. In the southern portion, closely following the gorge ɜ Rockaway River, the terminal moraine of the great continental ɜr crosses the Highland area.

e Highlands are of littlė value for farming purposes, except in ortion composed of Paleozoic rocks (see Pl. II). Their rugged graphy, their thin soil, and the prevalence of large glacial bowl- which in places literally cover the surface, are discouragements great to be overcome, and the region has thus of necessity been in forest. This lack of agricultural development is doubtless due to the fact that large tracts are controlled by individuals corporations looking toward the development of the extensive ore deposits which are present in the region.

om the hydrographic standpoint the presence of forests is of much e, as the Highland tributaries are all clear-flowing streams with nimum of sediment as contrasted with the more turbid waters of main stream.

he percentage of forests over the Highland region varies, being test north of the terminal moraine, where it ranges from 75 to 90 cent. South of the moraine the territory is well cultivated, and forests occupy 30 per cent of the area.

wing to the general rugged nature of the region and the thin soil, population amounts to only 64 to the square mile, and is largely centrated in a few towns, the most important of which are Boon-, Dover, Rockaway, Butler, Bloomingdale, and Newfoundland; remainder of the area is practically unsettled.

THE CENTRAL BASIN.

Adjoining the Highlands on the southeast lies the central basin, a rked depression 8 to 12 miles wide and 32 miles long, bounded on west by the easterly escarpment of the Highlands, which rise in ld relief about 700 feet from the floor of the basin, and on the north- st and south by the crescent-shaped and concentric ridges of the atchung or Orange Mountains, which rise with almost equal bold- ss, but to an altitude somewhat less. Geologically the floor of the sin is composed of Triassic sandstones and shales, which are much fter than the hard rocks of the surrounding crystalline Highlands d the trap ridges of the Watchung Mountains. A few small trap lges are found within the basin. Pl. II shows the general relations these rocks.

Through processes of erosion several hundred feet of the Triassic ndstones have been washed away in this area, so that in general the or now stands at an elevation of about 180 feet above tide water.

An important feature of the central basin is the large area occupied y marsh or wet lands, which are easily flooded even in moderate rises f the stream, and which become widely submerged in extraordinary

floods. Their extent is 29,308 acres, or 17 per cent of the area of the basin. The distribution of the wet lands is as follows:[a]

Wet lands in Passaic Basin.

	Acres
On Passaic River above Chatham	[illegible]
On Passaic River from Chatham to Two Bridges, including Whippany and Rockaway	[illegible]
On Pompton River above Two Bridges	[illegible]
On Passaic River from Little Falls to Two Bridges	[illegible]
Total above Little Falls	[illegible]

It has been satisfactorily demonstrated that during and for an indefinite period after the Glacial epoch the basin was occupied by a large body of water, approximately 200 square miles in extent, which has been geologically designated as "Lake Passaic."[b] Extensive morainal deposits at the outlet of the basin near Little Falls and Paterson, with the possible assistance of masses of ice, formed the barrier which kept the waters of the lake in place. Evidence of this phase of the region's history is found in the widespread lacustrine deposits, which are responsible for the remarkable flatness of the surface over the northern half of the basin, the striking contrast of which to the surrounding mountains has already been mentioned. Further evidences of the Glacial lake stage are also found in the great marshes which have remained to the present day. Pl. III, taken from Second Mountain at Singac, looking north to west, shows the portion of the wet lands in the middle part of the central basin; it also shows the central section of the valley formerly occupied by Lake Passaic.

The Passaic River proper passes through this basin, entering it as a small stream in the southwestern portion and flowing generally northward in a meandering course until it crosses the barriers of Second Mountain at Little Falls, and First Mountain a few miles farther north, at Great Falls, Paterson. The drop in the first instance is about 40 feet, and in the second 70 feet. (See Pl. IV, A and B.)

Into this central basin the principal tributaries, with one exception, discharge their waters, and as the gradients of all of them are steep after heavy rains they quickly pour into the flat area such a volume of water that it is unable to pass the outlet at Little Falls, and for days and even weeks large portions of the wet lands remain under water.

The terminal moraine of the great glacier, which was noticed in the Highland area, is also found in this portion of the watershed, where it crosses in a line of low and much confused hills extending from Summit to Morristown.

The central basin is an agricultural country with relatively few centers of population, the most important being Morristown, Summit

[a] Final Report New Jersey Geological Survey, Vol. III.
[b] Kümmel, Report of the State Geologist of New Jersey, 1893.

tham, Madison, Morris Plains, Pompton, and Whippany. The ulation is 120 to the square mile, and 29 per cent of the area is in st. The East Jersey Water Company maintains a pumping station Little Falls, from which point approximately 63,000,000 gallons of er per day are taken.

he physiographic features most affecting the hydrography of this tion of the watershed are, first, the narrow gorge of the river at le Falls, which quickly becomes congested in times of flood (Pl. A and B), and, second, the large expanse of the wet lands and the level-lying valley floor, which are easily submerged when the gestion at Little Falls takes place (Pl. III).

Although the frequent flooding in the central basin works considerable hardship and even loss to the farming class there located, it is nevertheless, a feature which has a beneficial effect upon the lower tion of the valley beyond Paterson, as it provides natural storage accumulated waters and prevents widespread floods in the thickly abited manufacturing and suburban districts in the lower valley.

THE LOWER VALLEY.

After leaving the short series of rapids, falls, and quiet stretches om Little Falls to Paterson, the river enters the lower valley through ich it flows to its mouth at Newark Bay. The drainage area of this ction to Little Falls is 178 square miles, the main stream being 29.1 iles long. Nine and one-quarter miles below Paterson it receives only important tributary in the lower valley, viz, Saddle River, hich has a drainage area of 60.7 square miles. Just above the outh of this stream, at Dundee, the waters of the river are held by a am 450 feet long, whose crest is 27 feet above mean tide. For 4 iles below this dam the river has a total drop of 6 feet to Passaic, om which point 13½ miles to Newark Bay it is a narrow tidal stuary.

The right bank of the river at Passaic is a low bench and it is ooded in times of very high water. A large portion of the manufacturing section of the city of Passaic is located here, and most of the ijury sustained by the 1902 flood was caused by the destruction of erchandise on the lower floors of the factories and warehouses. On he left bank of the stream, opposite the city of Passaic, is another ow-lying area, forming a basin which was evidently occupied by the tream in earlier stages. The general level of this area lies but a few eet above tide water, and is likewise subject to overflow. It is the ite of the borough of Wallington, a residence district. About midway in its extent from north to south this flat is crossed by the main ine of the Erie Railroad on an embankment of gravel and other material. The embankment ends at the left bank of the river.

One of the important features of the lower valley is its great popu-

lation, which has been concentrated there by reason of the natural advantages of its water front on the lower Passaic, the proximity to Paterson and Passaic, and the proximity to New York City. In the district, which has an area of about 60 square miles, there are over forty cities, towns, and boroughs, representing a combined population of about 4,200 per square mile. Municipal improvements which accompany the growth of population influence the drainage of the area to some extent, by reason of the construction of large areas of paved and macadamized roads which constitute "quick spillway surfaces.

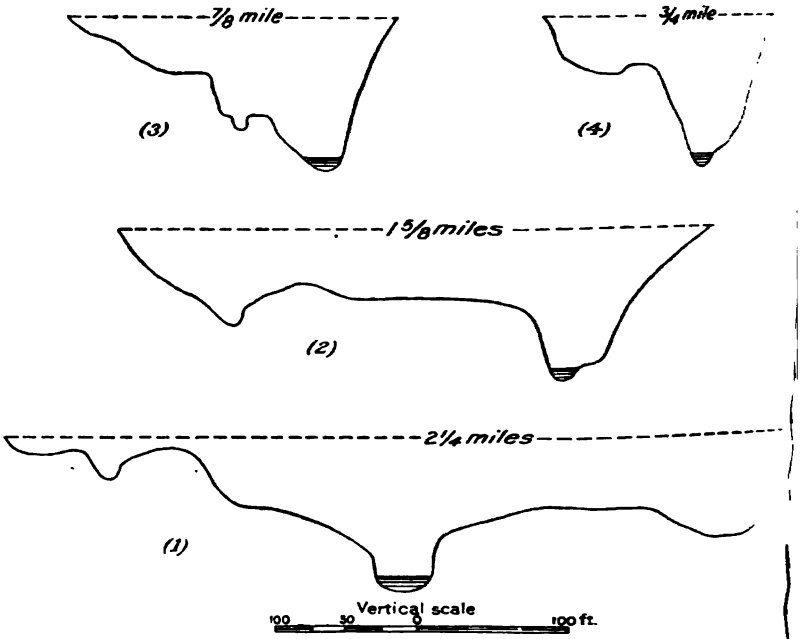


FIG. 1.—Cross sections of Passaic Valley from Clifton to Newark. 1. At Clifton. 2. At Delawanna, 5¼ miles below Clifton. 3. At North Newark, 10¼ miles below Clifton. 4. At Newark, 11¼ miles below Clifton.

A striking feature of the lower course of the river, which especially affects it in times of flood, is found in its physiographic relations. From Paterson to Passaic the stream flows in a wide open "old valley;" but from Passaic to its mouth, contrary to usual conditions, its valley assumes more and more the aspect of younger topography, until when near its mouth, just above Newark, it follows a narrow canyon-shaped opening whose sides, especially on the eastern bank, are precipitous. Attention in this connection is called to the series of profiles in fig. 1, made at different points from Clifton and Newark, and to the accompanying table of widths at the 100-foot contour in which the cramping of the valley is readily appreciated.

Physiographic phenomena in the neighborhood of Passaic and Rutherford, together with the striking aspect of the lower valley

seem to indicate that in pre-Glacial times the stream discharged its waters through the gap in the low sandstone ridge at Rutherford now occupied by the Erie Railroad, and that the lower valley, from Newark to Passaic, drained northward through a small tributary which joined the main stream at Rutherford, but owing to the obstruction of the river by extensive glacial filling across its bed in the notch at Rutherford, it was forced to seek a new outlet through the valley of a tributary meeting it from the south.

Whether this be the explanation of the narrowness of the lower valley or not, the restricted limits of this section have an important bearing upon the action of the stream in times of flood, producing a congestion of the waters in excessive freshets which has been of great pecuniary damage to the city of Passaic and the surrounding districts. The building of docks at Newark and the erection of solid masonry piers for bridges, together with a number of elevated causeways for turnpikes crossing the stream and flat lands adjacent, have still further narrowed the already too limited outlet below Passaic.

Like the central basin, the floor of the lower valley is composed of soft Triassic sandstones, more or less overlain by glacial drift.

TRIBUTARIES OF PASSAIC RIVER.

SADDLE RIVER.

In ascending the Passaic from its mouth, Saddle River is the first and only tributary of size in the lower valley. This stream rises in New York, 3 miles north of the State line, flows almost due south for 17 miles, and reaches the Passaic at Garfield. Its course is wholly in the red-sandstone area, which is thickly covered with glacial drift. It has an average fall of 34.1 feet per mile. Its catchment area amounts to 60.7 square miles. The country which it drains is a fertile farming land, with a population of 122 to the square mile, and 28 per cent of its area is still forest. Floods on this stream rise rapidly, remain high but a few hours, and decline as quickly as they arise; the most severe floods occupy from one to two days.

RAMAPO RIVER.

The Ramapo rises in Orange County, N. Y., upon the crystalline highlands and Paleozoic areas; it cuts the trend of the crystalline ridges in a deep gorge, falling 280 feet in 16 miles, from Turners to Suffern, above which point it drains 112.4 square miles. Entering New Jersey at Suffern, it reaches the sandstone area and flows 12 miles to Pompton along the contact of the sandstone and the crystalline rocks, with a fall of 5.7 feet to the mile. Its tributaries in this stage are few, and are mostly from the precipitous slopes of the highlands on its right bank, so that the river as a whole may be regarded as a highland stream. At Pompton, 10 miles below Suffern, the river passes over a natural fall, increased by a dam to 23 feet in height (Pl. VI, *A*); above this dam there is a pond 202 acres in extent.

After passing the dam at Pompton the Ramapo enters the central basin and joins the Pequanac and Wanaque to form the Pompton River. The stream is well adapted to the development of power, and several hundred horsepower upon it are already improved; 75 per cent of the area is in forest, and the population is 58 to the square mile.

WANAQUE RIVER.

Joining the watershed of the Ramapo on the south and west is the drainage basin of the Wanaque; the topography of its watershed is almost identical with that of the former stream, and its waters are gathered entirely from the Highland area; its source is Greenwood Lake, a lake of glacial origin, which lies between heavily wooded mountains and was formed by the accumulation of drift across a narrow valley. It is 6 miles long with a uniform breadth of five-eighths of a mile. It has a surface area of 1,920 acres and an altitude of [illegible] feet above sea level. At its outlet is a stone dam 181 feet long and [illegible] feet high. From Greenwood Lake the river has a length of [illegible] with a general southerly course, mostly through longitudinal valleys of the crystalline Highlands, until it emerges at Pompton and enters the Central Basin, where it joins the Pequanac and Ramapo to form the Pompton. From Greenwood Lake to its junction with the Pequanac it falls 451 feet, or about 26 feet to the mile; 80 per cent of the area of its watershed is in forest, and its population is but 3[illegible] to the square mile.

PEQUANAC RIVER.

The watershed of the Pequanac also lies entirely in the Highlands and adjoins that of the Wanaque on the south; in the topography of its watershed and in its general characteristics it closely resembles the area drained by the Wanaque and Ramapo. The Pequanac has a length of 31 miles and rises on the western portion of the Highland belt, which it crosses to the east in a narrow gorge; it has an average fall of 35.1 feet to the mile, falling about 1,100 feet from source to mouth. From a point 2 miles above its mouth to Newfoundland, a distance of 12½ miles, the fall is 45 feet to the mile.

The Pequanac River has been extensively utilized as a source of public water supply; it has natural storage in several ponds of moderate size upon its drainage area, and in the following three large reservoirs built by the East Jersey Water Companies; Oak Ridge reservoir, 16 miles from its mouth, with an area of 383 acres; Clinton reservoir, 13 miles from its mouth, with an area of 423 acres, and Oldistear reservoir, about 23 miles above its mouth, with an area of [illegible] acres. The water collected in these reservoirs is conducted in an open stream to the Makopin intake, a small reservoir 9.5 miles above the mouth, having an area of 12 acres; from this point it is conducted to the city of Newark in a steel conduit. Seventy-five per cent of the area of its watershed is in forest.

A. DAM AT LITTLE FALLS.

B. PASSAIC FALLS AT PATERSON.

ROCKAWAY RIVER.

third tributary on the Highland area, whose drainage area lies ost wholly in the Highlands, is the Rockaway; its area adjoins ; of the Pequanac on the south; it is 40 miles long from source to ıth and has a fall of 780 feet or 19.5 feet per mile. It has exten- storage facilities in natural ponds, among them Splitrock Pond, ons Pond, Denmark Pond, Green Pond, and Opennaki Lake. ower is developed at Boonton on the edge of the Highlands 9 miles ve its mouth, and is second only to those at Paterson and Little ls. Like the Pequanac its course is across the Highland ridges, its fall is less uniform than that of the last-named stream. Above ›nton the stream drains 118 square miles, the population of which 13 to the square mile; 82 per cent of the area is in forest. As the ›am leaves the Highlands at Boonton it has a rapid fall to Old ›nton, 240 feet in 1.5 miles; at Old Boonton it enters the central ›in, and for 2 miles has a fall of 32 feet per mile; 6 miles below it ıs the Passaic, with a fall of 2.3 feet per mile. The area of the ›ire watershed is 138.4 miles.

WHIPPANY RIVER.

This is a small stream which heads in the Highlands, with most of course in the morainic hills north of Morristown. It is about 17 les long, and from its highest source has a fall of 640 feet; it has a ›inage area of 71.1 square miles, with a population of 124 to the uare mile; 36 per cent of its area is in forest; 25.4 square miles of area lie in the Highland area and 45.7 square miles in the central sin. The Whippany is known as a quick-spilling stream.

UPPER PASSAIC RIVER.

The Upper Passaic heads in the Highland area and descends into e upper portion of the central basin as a very small stream; in this ırt of the basin flat lands are found subject to overflow, covering an ›a of nearly 10,400 acres; they are confined on the north by the rminal moraine, on the west by the Highlands, and on the south and ıst by Long Hill or Third Watchung Mountain, the western member the concentric series of trap ridges. The Passaic drains this basin ı a narrow gorge cutting the Third Mountain at Millington, from hich point it descends to Chatham, a distance of 17 miles, where it rosses the terminal moraine and enters the central basin proper.

Under present conditions the characteristic functions of the three ıain divisions above described may be stated as follows: The High- ınd area is the chief gathering ground; the central basin, the reser- oir area; the lower valley, the discharge artery. These functions ›re greatly intensified in times of flood.

SUMMARY.

For the better understanding of the more important relations of the Passaic system the profile of the river and its tributaries is inserted. Attention is particularly called to the important features which control flood conditions as they are illustrated in the diagram. The first of these is the gradient of the tributaries which enter the central basin from the Highland area. The diagram, especially in the cases of the Pequanac and Rockaway rivers, admirably shows the rapidity from the mountains to the flat valley in the last few miles of their courses. The same is true to a lesser extent of the Wanaque, Whippany, and Rahway rivers. The effect of these comparatively steep grades is emphasized in times of flood by the still steeper valley sides and the high pitch of the many lateral runs and by the abundance of the exposed rock surface of the region. When to these conditions are added a covering of snow or ice and a frozen ground, as was the case at the time of the flood under discussion, the whole region becomes exceedingly "quick spilling" in spite of its large percentage of forest and pours its waters into the central basin with great rapidity.

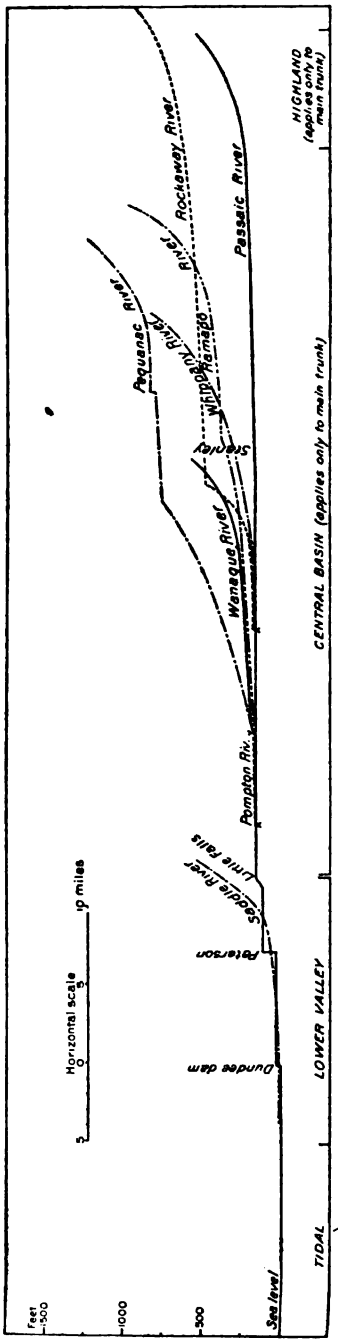


FIG. 2.—Profile of Passaic River and tributaries.

The second important condition indicated by the profile is the exceedingly flat nature of the central basin. From Two Bridges, the mouth of the Pompton River, to Lower Chatham Bridge, 27 miles above by stream, the total fall is only 7 feet, and from Little Falls to Newark, the limits of the flat part of the central basin, a distance of 27 miles, the total fall is only 19 feet. In this part of the watershed occur the great swamp areas which overflow and remain submerged under flood discharges.

The third important feature is found in the fact that the tributaries w

ish the largest percentage of water to the main stream enter it in central-basin area and above the gorge at Little Falls, which, as been described, is but a narrow outlet.

ie fourth interesting and suggestive feature is that from the out- f the central basin the main trunk of the river reaches sea level hree quick descents at Little Falls, Paterson, and Dundee, between h lie stretches having very little fall. The effect of these level hes in each case is to retard and accumulate waters which are red into them, thus helping to produce local overflows which dur- floods are often disastrous.

s a summary of the important features of the drainage area the owing table is added, which shows the total drainage area of the le system in square miles as well as that of the individual tribu- es; also their lengths, proportion of forested areas, fall in feet, other features.

le showing drainage areas, forest areas, fall in feet, and gradient of the Passaic and its tributaries.

	Drainage area.	Length of river.	Forests upon watershed.	Drainage area on crystalline highlands.	Drainage area in upper basin.	Drainage area in lower valley.	Fall.	Average gradient.
	Square miles.	*Miles.*	*Per cent.*	*Square miles.*	*Square miles.*	*Square miles.*	*Feet.*	*Feet per mile.*
saic proper	299.0	83.5	44	10.0	[a]129.9	115.5	580	6.9
dle River	60.7	17.0	28	0.0	0.0	60.7	540	31.8
npton River	24.8	6.0	69	0.0	24.8	0.0	10	1.66
napo River	160.7	34.0	72	136.0	24.7	0.0	650	18.8
naque River	109.6	16.5	83	109.6	0.0	0.0	550	33.9
nanac River	84.8	31.0	78	83.8	1.0	0.0	1,090	35.1
kaway River	138.4	40.0	80	118.2	20.2	0.0	1,030	25.7
ippany River	71.1	20.0	36	25.4	45.7	0.0	680	34.0
Total	949.1	.....	.....	483.0	289.9	176.2	.....	.....

[a] 43.6 square miles above Chatham.

FLOW OF PASSAIC RIVER.

Various short-term measurements of the flow of the Passaic River ve been made by engineers, and the records appear scattered through ports which have not received wide distribution. Much informa- on regarding the stream was collected and compiled by Mr. C. C. Vere- ule, and included in his admirable report to the geological survey the State of New Jersey.[a] In this report is a series of flow curves vering the years 1877 to 1893.[b] The values represented by these rves were computed from gage-height records, maintained during

[a] Water Supply: Geol. Survey New Jersey, Vol. III, 1894. [b] Ibid., p. 154.

the period mentioned above, along the river between Little Falls and Dundee dam. A tabulation of these values appears in Water-Supply and Irrigation Paper No. 72, and for convenience is reproduced here.

Daily flow of Passaic River at Paterson and Dundee.

[Inches on watershed.]

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1877	0.029	0.081	0.202	0.107	0.032	0.021	0.015	0.015	0.013	0.09[illegible]	0.14[illegible]	[illegible]
1878	.084	.138	.126	.046	.055	.054	.027	.053	.018	.019	.05[illegible]	[illegible]
1879	.027	.071	.182	.143	.055	.034	.035	.051	.031	.010	.012	[illegible]
1880	.115	.092	.080	.030	.036	.012	.013	.....	.012	.011	.02[illegible]	[illegible]
1881	.037	.131	.215	.042	.029	.056	.037	.010	.010	.010	.01[illegible]	[illegible]
1882	.069	.171	.127	.117	.105	.061	.061	.018	.197	.043	.09	[illegible]
1883	.031	.115	.106	.098	.053	.024	.033	.013	.013	.047	.04	[illegible]
1884	.092	.215	.157	.094	.067	.022	.043	.030	.010	.019	.05	[illegible]
1885	.137	.081	.066	.115	.054	.016	.015	.026	.010	.027	.09	[illegible]
1886	.109	.189	.097	.114	.113	.034	.017	.018	.010	.018	.02	[illegible]
1887	.105	.171	.118	.087	.039	.069	.080	.052	.014	.027	.02	[illegible]
1888	.145	.138	.166	.195	.024	.014	.013	.034	.100	.015	.05	[illegible]
1889	.192	.087	.104	.137	.104	.059	.088	.145	.142	.055	.25	[illegible]
1890	.066	.118	.107	.099	.087	.051	.031	.036	.151	.084	.07	[illegible]
1891	.192	.205	.169	.076	.029	.015	.014	.023	.023	.012	.03	[illegible]
1892	.158	.052	.065	.054	.045	.038	.019	.019	.014	.011	.09	[illegible]
1893	.121	.203	.227	.130	.155	.077	.025	.023	.020	.041	.....	[illegible]
Monthly average	.101	.133	.136	.099	.064	.039	.033	.035	.050	.032	.05	[illegible]

Discharge measurements of Pompton River at Two Bridges, N. J.

Date.	Gage height.	Discharge.
1901.	*Feet.*	*Second-feet.*
May 4	3.35	[illegible]
May 24	2.20	[illegible]
June 15	1.60	[illegible]
July 11	1.35	[illegible]
August 15	1.78	[illegible]
August 26	8.32	[illegible]
October 26	1.30	[illegible]
November 22	1.00	[illegible]

A. LITTLE FALLS GORGE AT LOW WATER.

B. LITTLE FALLS GORGE AT HIGH WATER.

Discharge measurements of Passaic River at Two Bridges, N. J.

Date.	Gage height.	Discharge.
1901.	*Feet.*	*Second-feet.*
4	3.88	1,345
4	4.20	1,198
24	3.05	626
e 15	2.50	522
y 11	2.20	337
gust 15	2.75	589
gust 26	9.35	3,882
ober 26	2.20	230
vember 23	1.92	181

Estimated monthly discharge of Passaic River at Two Bridges, N. J

[Drainage area, 360 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
Iay [a]	2,000	623	1,105	3.07	3.54
une 1–22			779	2.16	1.76
uly	1,007	137	448	1.24	1.43
ugust	3,858	363	1,409	3.91	4.51
eptember	1,650	271	632	1.76	1.96
Octobber	959	225	472	1.31	1.51
November	719	181	321	.89	.99
December	4,445	225	1,015	2.82	3.26

[a] Approximate.

Estimated monthly discharge of Pompton River at Two Bridges, N. J.

[Drainage area, 360 square miles.]

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1901.				
May [a]	2,751	893	1,529	4.25
June 1-22	----------	----------	1,015	2.82
July	1,254	195	541	1.50
August	5,342	255	1,834	5.09
September	2,240	221	848	2.35
October	1,181	221	533	1.48
November	1,001	195	322	.89
December	6,328	300	1,441	4.00

[a] Approximate.

Daily gage height, in feet, of Pompton River at Two Bridges, N. J., for

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	------	3.90	1.20	1.70	4.00	2.30	[illegible]
2	3.10	3.75	1.85	1.45	3.80	2.00	[illegible]
3	3.50	3.70	2.05	1.55	3.50	2.00	[illegible]
4	3.35	3.40	2.25	1.35	2.95	2.00	[illegible]
5	2.95	3.05	2.45	1.20	2.60	1.75	[illegible]
6	2.65	2.80	2.60	1.20	2.45	1.65	[illegible]
7	2.45	2.60	2.65	3.25	2.20	1.50	[illegible]
8	2.15	3.51	2.65	3.90	2.00	1.40	[illegible]
9	2.20	3.50	1.85	3.15	2.85	1.30	[illegible]
10	2.85	2.80	1.50	2.65	1.65	1.30	[illegible]
11	4.50	2.45	1.30	2.45	2.65	1.30	[illegible]
12	4.70	2.15	1.45	2.25	2.65	1.30	[illegible]
13	4.30	1.95	1.60	2.05	1.70	1.25	[illegible]
14	3.60	1.60	1.60	2.00	1.50	1.95	[illegible]
15	3.55	1.50	1.40	1.85	1.50	2.55	[illegible]
16	3.20	1.50	1.15	1.55	1.85	2.45	[illegible]
17	2.85	1.45	1.35	1.50	2.05	2.30	[illegible]
18	2.60	1.45	2.65	3.20	2.00	2.15	[illegible]
19	2.65	1.25	1.65	4.55	2.00	2.00	[illegible]
20	2.45	1.20	1.60	4.25	1.85	1.75	[illegible]
21	2.50	1.15	1.20	3.60	1.45	1.60	[illegible]
22	2.15	1.00	1.00	5.15	1.40	1.50	[illegible]
23	2.30	1.00	1.00	5.00	1.40	1.40	[illegible]
24	2.15	1.15	1.00	6.50	1.40	1.30	[illegible]
25	2.40	1.10	1.00	8.25	1.30	1.30	[illegible]
26	2.75	1.15	1.00	7.15	1.20	1.30	[illegible]
27	2.80	.90	1.00	6.10	1.10	1.25	[illegible]
28	3.50	.90	1.00	5.15	1.10	1.20	[illegible]
29	3.50	.90	1.30	4.55	1.50	1.20	[illegible]
30	4.00	.90	1.75	4.05	2.50	1.10	[illegible]
31	4.00	------	1.75	3.85	------	1.10	[illegible]

aily gage height, in feet, of Passaic River at Two Bridges, N. J., for 1901.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	.....	4.75	1.80	2.75	4.95	3.15	2.00	2.00
	3.90	4.55	2.10	2.50	4.80	3.00	2.00	2.00
	4.25	4.55	2.30	2.50	4.40	3.00	2.00	2.05
	4.20	4.30	2.70	2.50	4.10	3.00	2.00	2.60
	4.05	3.95	3.10	2.30	3.75	2.85	2.00	2.95
	3.60	3.65	3.60	2.30	3.50	2.65	2.00	2.85
	3.30	3.45	3.65	4.20	3.20	2.45	2.00	2.70
	3.05	4.35	3.45	4.80	3.00	2.40	2.00	2.65
	2.95	4.05	2.70	4.00	2.90	2.30	2.00	2.50
	3.65	3.85	2.25	3.70	2.60	2.25	2.00	2.40
	5.65	3.40	2.20	3.45	2.50	2.20	2.00	2.95
	5.60	3.15	2.45	3.25	2.60	2.20	2.05	2.85
	5.15	2.95	2.55	3.05	2.60	2.20	2.20	2.80
	4.85	3.00	2.50	3.00	2.55	2.85	2.30	2.85
	4.45	2.50	2.30	2.75	2.45	3.55	2.10	3.20
	4.05	2.40	2.25	2.50	2.65	3.45	2.10	6.80
	3.90	2.30	2.40	2.50	2.85	3.20	2.10	5.90
	3.40	2.15	3.55	4.10	2.80	2.95	2.10	5.15
	3.50	1.95	2.60	5.55	2.65	2.80	2.00	4.85
	2.95	1.95	2.50	5.20	2.50	2.60	2.00	4.20
	3.15	1.90	2.15	4.50	2.45	2.50	2.00	3.00
	3.00	1.85	2.00	6.15	2.40	2.50	2.00	3.00
	3.00	1.90	2.00	6.00	2.20	2.20	1.90	2.95
	3.05	2.00	2.00	7.05	2.20	2.20	2.35	2.70
	3.25	2.05	2.00	9.30	2.20	2.20	2.65	2.55
	3.60	1.90	2.00	8.50	2.10	2.10	3.05	2.40
	3.95	1.90	2.00	7.35	2.10	2.05	3.00	3.20
	4.40	1.80	2.00	6.35	2.10	2.00	3.00	3.80
	4.40	1.80	2.20	5.45	2.40	2.00	2.65	3.70
	4.65	1.80	2.70	5.00	3.35	2.00	2.30	8.70
	4.90	.....	2.75	5.10	.....	2.00	.....	10.45

Daily gage height, in feet, of Pompton River at Two Bridges, N. J., for

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	8.35	3.00	10.40	4.35	3.30	2.15	2.50	2.75	1.30	4.55	[illegible]
2	7.55	3.50	14.40	4.15	3.05	1.75	2.25	2.65	1.20	4.95	[illegible]
3	6.45	3.70	14.00	3.40	2.80	1.30	2.00	2.55	1.10	4.70	[illegible]
4	6.25	3.50	10.80	3.25	2.95	1.30	2.10	2.30	1.10	4.45	[illegible]
5	5.15	3.40	9.75	3.15	2.55	1.20	2.00	2.10	1.10	4.45	[illegible]
6	4.00	3.30	8.40	3.00	2.40	1.20	1.85	2.00	1.10	4.75	[illegible]
7	3.30	2.60	7.15	3.15	2.15	1.10	1.65	1.85	1.00	4.50	[illegible]
8	2.95	2.10	6.15	3.65	2.00	1.10	1.45	1.70	1.10	4.25	[illegible]
9	2.55	1.90	6.55	5.30	2.00	1.10	1.40	1.60	1.10	3.95	[illegible]
10	2.35	1.70	7.35	6.60	1.85	1.00	1.40	1.50	1.20	3.60	[illegible]
11	2.25	1.50	7.70	6.60	1.50	1.00	1.35	2.55	1.25	3.30	[illegible]
12	2.35	1.50	7.45	6.15	1.30	1.00	1.30	2.95	1.30	4.00	[illegible]
13	2.30	1.40	7.30	5.80	1.30	1.05	1.20	3.60	1.40	5.05	[illegible]
14	2.20	1.40	7.50	4.55	1.30	1.25	1.20	3.50	1.50	4.85	[illegible]
15	2.05	1.30	7.15	4.05	1.20	1.30	1.20	3.50	1.50	4.65	[illegible]
16	1.50	1.20	7.00	3.60	1.20	1.30	1.20	2.25	1.40	4.15	[illegible]
17	1.60	1.20	5.90	3.40	1.20	1.30	1.10	3.05	1.15	3.65	[illegible]
18	1.50	1.20	6.60	3.10	1.15	1.30	1.20	2.70	1.10	3.00	[illegible]
19	1.45	1.10	5.55	2.60	1.10	1.25	1.30	2.55	1.10	3.00	[illegible]
20	1.30	1.20	4.65	2.50	1.20	1.25	1.30	2.65	1.10	2.95	[illegible]
21	1.30	1.30	4.35	2.50	1.20	1.35	1.35	2.45	1.10	2.80	[illegible]
22	5.75	1.50	4.10	2.40	1.20	1.70	1.50	2.25	1.10	2.65	[illegible]
23	7.75	1.70	3.75	2.40	1.10	1.65	1.45	2.15	1.00	2.40	[illegible]
24	6.85	1.85	3.40	2.30	1.10	1.50	1.40	1.90	1.10	2.16	[illegible]
25	5.45	2.45	3.15	2.20	1.20	1.50	1.75	1.60	1.25	1.85	[illegible]
26	4.35	4.30	2.85	1.80	1.75	1.50	2.15	1.45	2.70	1.75	[illegible]
27	4.30	7.20	2.60	1.65	2.15	1.65	2.20	1.20	3.30	1.65	[illegible]
28	4.05	8.60	2.45	1.60	2.75	1.55	2.20	1.35	3.95	2.40	[illegible]
29	3.45	.....	3.30	2.40	2.80	1.35	2.15	1.40	4.60	2.55	[illegible]
30	3.15	.....	4.55	3.00	2.45	2.45	2.70	1.30	4.55	3.00	[illegible]
31	3.20	.....	4.45	.....	2.25	.....	2.85	1.30	.....	3.90	[illegible]

A. FALLS, POMPTON LAKE.

B. LITTLE FALLS GORGE, LOOKING UNDER MORRIS CANAL VIADUCT, HIGH WATER.

ily gage height, in feet, of Passaic River at Two Bridges, N. J., for 1902.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	9.25	3.70	11.55	5.25	4.40	3.10	3.30	3.75	2.30	5.55	3.75	2.20
	8.25	4.35	13.50	5.15	4.10	2.70	3.25	3.65	2.20	5.95	3.70	2.45
	7.45	4.50	12.80	4.65	3.80	2.40	3.00	3.55	2.15	5.70	3.65	2.70
	7.40	4.30	11.80	4.40	3.95	2.30	3.10	3.30	2.00	5.55	3.55	3.00
	7.05	4.15	10.75	4.15	3.55	2.20	3.00	3.10	2.00	5.45	3.35	3.00
	6.90	4.00	9.40	4.00	3.40	2.15	2.85	3.00	2.00	5.75	3.30	3.10
	4.50	3.80	8.15	4.15	3.15	2.10	2.65	2.85	2.00	5.50	3.20	3.10
	3.90	3.60	7.20	4.60	3.00	2.10	2.55	2.70	2.10	5.25	3.20	3.20
	3.50	3.40	7.50	6.25	3.00	2.10	2.40	2.60	2.10	4.95	3.05	3.35
	3.20	3.20	8.35	7.65	2.85	2.00	2.40	2.45	2.20	4.60	2.90	3.25
	3.00	3.20	8.70	7.65	2.50	2.00	2.35	3.50	2.25	4.30	2.80	3.10
	3.40	2.90	8.45	7.15	2.30	2.00	2.30	3.95	2.30	5.55	2.55	3.10
	3.25	2.60	8.30	6.70	2.30	2.20	2.20	4.60	2.40	6.05	2.45	3.00
	3.10	2.30	8.50	5.55	2.30	2.30	2.20	4.50	2.50	5.85	2.35	2.90
	2.80	2.10	8.15	5.10	2.30	2.30	2.20	4.50	2.50	5.65	2.30	2.85
	2.50	2.10	8.00	4.60	2.20	2.20	2.20	4.25	2.40	5.15	2.30	2.80
	2.50	2.10	6.90	4.40	2.20	2.30	2.10	4.05	2.15	5.65	2.30	6.65
	2.50	2.10	7.55	4.10	2.15	2.30	2.20	3.70	2.10	4.40	2.20	9.25
	2.45	2.20	6.75	3.40	2.10	2.25	2.25	3.55	2.10	4.00	2.20	9.20
	2.40	2.30	5.65	3.50	2.20	2.25	2.30	3.60	2.10	3.95	2.20	9.00
	2.00	2.45	5.35	3.50	2.20	2.40	2.35	3.35	2.10	3.80	2.20	9.00
	5.65	2.65	5.10	3.40	2.20	2.80	2.50	3.20	2.10	3.65	2.10	8.55
	8.80	2.70	4.75	3.40	2.10	2.75	2.45	3.05	2.00	3.40	2.00	8.95
	7.95	3.40	4.40	3.30	2.10	2.60	2.40	2.90	2.10	3.05	2.00	10.55
	6.80	3.90	4.15	3.20	2.25	2.60	2.75	2.60	2.25	2.85	2.20	10.25
	5.80	5.45	3.75	2.80	2.60	2.50	3.15	2.35	2.85	2.75	2.30	9.45
	5.70	8.15	3.50	2.65	2.95	2.65	3.20	2.20	3.60	2.65	2.45	9.05
	5.45	9.60	3.35	2.65	3.35	2.55	3.20	2.35	4.55	3.40	2.50	8.20
	4.75	------	4.25	3.30	3.65	2.40	3.15	2.40	5.60	3.60	2.40	7.65
	4.40	------	5.55	3.90	3.45	3.30	3.70	2.30	5.55	4.00	2.30	7.65
	3.80	------	5.35	------	3.25	------	3.85	2.30	------	3.90	------	7.55

Estimated monthly discharge of Passaic River at Two Bridges, N. J.

[Drainage area, 360 square miles.]

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean	Second-feet per square mile.
1902.				
January	3,832	225	1,616	4.49
February	4,011	271	1,003	2.79
March	[a] 11,600	863	2,863	[a] 7.95
April	3,016	527	1,424	3.96
May	1,375	271	618	1.72
June	839	225	408	1.13
July	1,103	271	550	1.53
August	1,475	317	808	2.24
September	1,975	225	488	1.36
October	2,200	527	1,467	4.08
November	1,055	225	534	1.48
December	4,496	317	2,071	5.75
The year	[a] 11,600	225	1,154	3.21

[a] Estimated.

Estimated monthly discharge of Pompton River at Two Bridges, N. J.

[Drainage area, 360 square miles.]

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1902.				
January	5,415	300	2,080	5.78
February	5,598	221	1,180	3.28
March	[a] 11,600	1,109	[a] 4,050	[a] 11.25
April	4,138	505	1,867	5.19
May	1,729	221	703	1.95
June	1,109	195	376	1.04
July	1,400	221	583	1.62
August	1,948	255	969	2.69
September	2,678	195	569	1.58
October	3,006	540	1,927	5.35
November	1,327	195	575	1.60
December	6,291	255	2,795	7.76
The year	[a] 11,600	195	1,473	4.09

[a] Estimated.

Miscellaneous measurements in Passaic watershed.

to.	Stream.	Locality.	Discharge.
92.			*Sec.-feet.*
26	Ramapo River	Mahwah, N. J	123
29	do	do	678
24	Rockaway River	Old Boonton, N. J	33
23	do	do	146
11	do	do	164
23	do	do	102
30	do	do	488
30	Pompton River	Pompton Plains, N. J	1,066
t. 26	Passaic River	Stanley, N. J	195
t. 30	do	do	431
t. 26	do	Millington, N. J	92
g. 28	Whippany River	Whippany, N. J	35.3
pt. 23	Pequanac River	Pompton, N. J	90
g. 22	Wanaque River	do	97

During the past year the Division of Hydrography has made current-meter measurements on both the Pompton and Passaic rivers near their junction at Two Bridges, and for low-water stages of the rivers these measurements show with fair accuracy the volume of both streams.

During the progress of floods, however, measurements taken at these stations can not be relied upon to furnish complete data of the discharge, for the reason that the Pompton, a comparatively swift-flowing stream, enters the Passaic, a sluggish stream, at nearly right angles, cutting across its current and acting as a temporary dam in backing up its waters to a greater or less extent. In this way the gage-height readings on the Passaic, which are taken just above the junction, do not in flood time bear their true value to the discharge of the stream.

Another feature which detracts from the accuracy of flood measurements at Two Bridges is the fact that both rivers overflow their banks and spread over a wide section of flat lands during high freshets; so that while the gage readings have a certain interest and value, they do not accurately record the true height of the water which should pass between the banks. Therefore in this discussion neither the discharge measurements nor the gage-height records have been considered.

Attention is particularly called to the fluviographs of the Passaic and Pompton rivers (figs. 3 and 4) made from daily gage heights and frequent current-meter discharge measurements at Two Bridges, at the junction of these streams. They clearly reveal several important features in the flow of the rivers above mentioned. In the considera-

tion of them it should be borne in mind that the drainage area both the Passaic and Pompton rivers above the point of measurement are nearly equal in extent, and, furthermore, that they are adjacent. There is, however, this important difference between them with respect to topography and physical conditions, namely, that the catchment

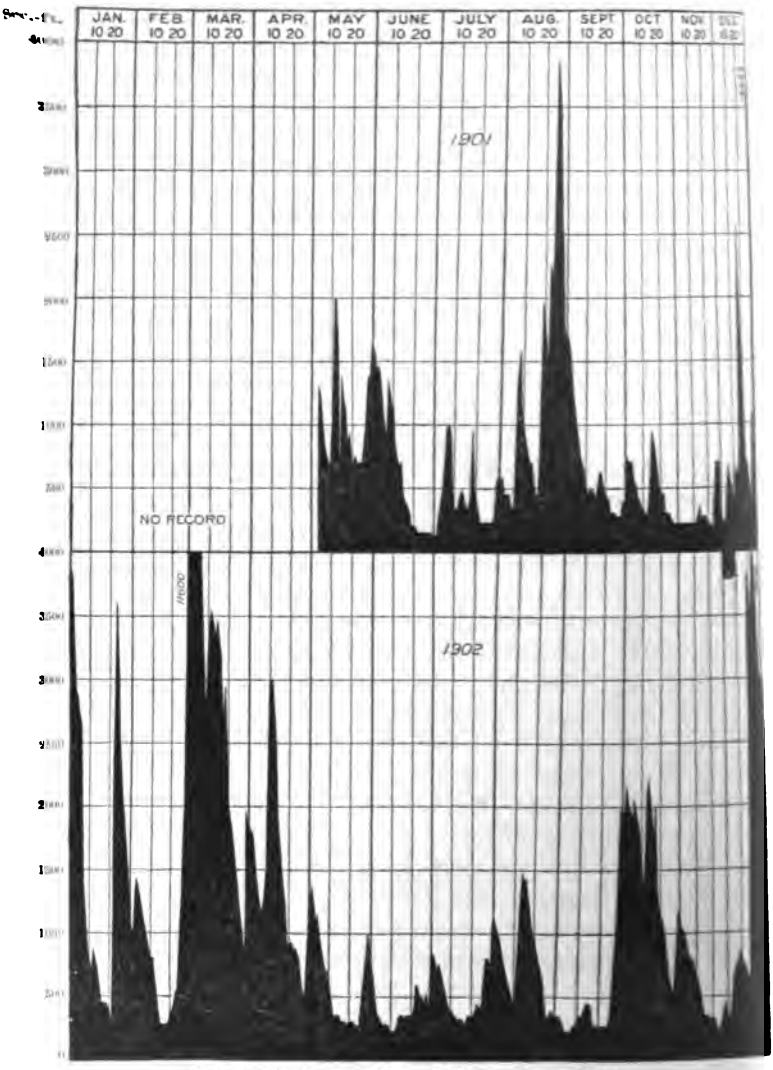


FIG. 3.—Discharge of Passaic River at Two Bridges.

basin of the Pompton lies almost entirely in a mountainous and heavily forested area of the Highlands, while that of the Passaic lies mainly in the comparatively flat cultivated area of the central basin.

The fluviographs show in a striking way the great irregularity in the flow of the streams. The quick and violent rises occur in a

ıths of the year, being naturally more prolonged in the spring than he summer season, and the normal and comparatively small flow he stream is during intervals between these rises.

'he rises occur on both streams simultaneously, as is to be expected n the proximity of the drainage areas, which naturally would

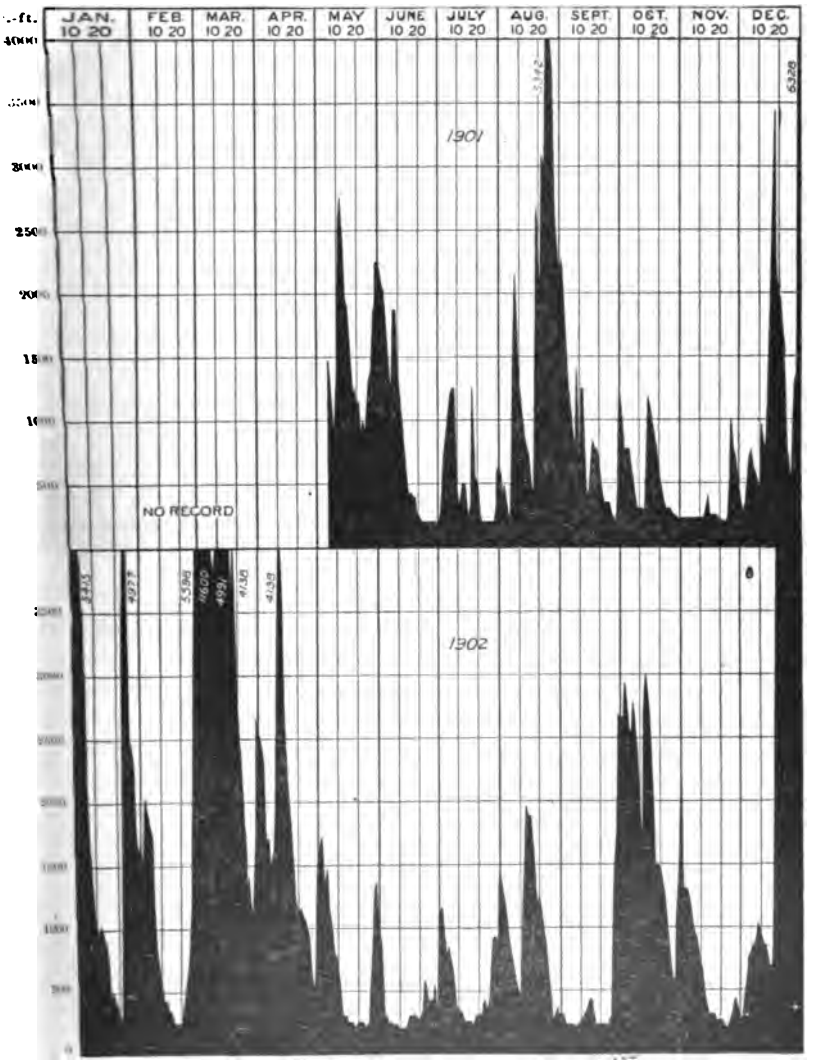


FIG. 4.—Discharge of Pompton River at Two Bridges.

receive about the same amount of precipitation during any given period. The rises on the Pompton River are in each case greater than those on the Passaic. This at first is difficult to understand, in view of the fact that the drainage area of the Pompton is heavily forested, while a large portion of the Passaic Basin, exclusive of the Rockaway,

whose waters in this instance are included, contains a comparatively small proportion of forests. In other words, the Pompton as compared with the Passaic watershed is quick spilling. A more inspection of other conditions serves to explain the anomaly of the flow; for not only are the grades on the Pompton watershed much steeper than those on the Passaic, the Rockaway River excepted, of this part of the Passaic Basin contains also the large areas of flat swamp lands previously referred to, which not only retard the flow of the streams, but, in the case of the swamp areas, act as a great natural reservoir for the waters at all times, absorbing the high waters which readily flood their surface, and contributing a constant supply back to the main stream in times of low-water flow. Owing to this regulating effect of the wet lands in the central basin, it is easy to account for the lower rises of the Passaic, as well as for the greater volume of its low-water flow, as compared with that of the Pompton, so clearly brought out by the fluviographs.

These characteristics of flow are, of course, greatly emphasized in times of extraordinarily high water, as during the flood under discussion. In such times, of course, the action of the waters becomes much complicated owing to the fact that the Pompton discharges its flood crest so rapidly that it acts as a temporary check to the Passaic, the waters of the former cutting across the channel of the latter at Two Bridges and increasing the flooding effect of the Passaic over the low lands above.

FLOOD OF 1902.

High water is not uncommon in the Passaic Valley. It occurs, as will be seen by reference to previous discharge tables and diagrams, several times a year, but though it comes with reasonable frequency it is not often violent. The large area of swamp and wet lands in the central basin is regularly flooded each spring, as are often farm lands adjoining these tracts. Lower down the valley waters may often rise to low bench lands and give some inconvenience in towns and villages. As far as the sewage pollution of the lower valley is concerned, these high waters are of a decided advantage, serving to flush that portion of the river and temporarily cleansing it from excess of sewage.

When, however, the precipitation on the drainage area becomes great, or when a variety of circumstances combine to deliver a large amount of water—as, for example, an accummulation of snow is rapidly melted on frozen ground by a warm and heavy rain—the flood conditions resulting in the lower parts of the valley are quite different in character. The central basin is widely flooded by a quick discharge of the highland tributaries, resulting in hardship and loss to the farming population of this area. The narrow gorge at Little Falls, whose capacity is made still less by the constricted opening of the old masonry span which supports the Morris Canal aqueduct just

A. ROCKAWAY RIVER AT BOONTON.

B. DAM AT DUNDEE.

I, *B*), is unable to discharge its waters fast enough to keep them flooding the lands above, while in the lower valley the waters de both the cities of Paterson and Passaic, doing great damage to manufacturing and residential properties and threatening the ller settlements located on the lower portion of the river.

loods of this nature have periodically occurred in this region and e resulted in widespread suffering and damage. Such a flood took e from February 25 to March 9, 1902, reaching its height at noon on day, March 2. It was the highest flood within the memory of the st inhabitant of the region, and owing to the fact that population manufacturing interests have greatly increased in portions of the ley during recent years, it was probably the most destructive. The its of the flood will be taken as the time during which the water el was above full bank. In the previously mentioned report of the w Jersey geological survey on the water resources of the State, the l bank flow at Dundee dam has been determined at 4,000 cubic t per second; our measurements and observations lead us to believe at 5,000 cubic feet is more nearly correct. In any case the differce is not sufficient to effect any significant discrepancy in determing the duration of the flood.

The discharge measurements hereinafter set forth were made with small Price current meter, according to the methods practiced by e Division of Hydrography, except in the cases of Little Falls and undee dams. At the latter points gages were read at short intervals d the amount of water was determined by Bazin's series modified conform with the local conditions and requirements.

PRECIPITATION IN THE PASSAIC VALLEY.

The records of numerous weather observation stations in the Passaic rainage area and those of other stations in the country immediately urrounding afford a trustworthy basis of measurement of precipitaion over the basin. The following table is a statement of the normal mount of precipitation at the various stations during the month of February, 1902. It should be borne in mind that the month of February is usually marked by considerable precipitation and that the normal for that period is, in most places, comparatively high. This result is a relatively large flow in river channels. Therefore an increase over the normal of 2 inches in the month of February means more, from the standpoint of damage by river floods, than it would in a dry season when the river had been in low stages. In other words, the addition of 2 inches of rainfall to the flow of a stream while it was running fairly high would cause more damage than would the addition of a similar amount to the river at a low stage.

Precipitation in inches in the Passaic Valley and adjoining country in F[illegible] 1902.

Station.	County.	Normal.	Total for month.	Departure from normal.	Greatest in [illegible] hours.	[illegible]
HIGHLAND REGION.						
Dover	Morris	4.16	6.93	2.77	[illegible]	[illegible]
Chester	do	4.30	5.31	1.01	1.70	[illegible]
Charlotteburg	do	4.97	6.85	1.88	2.65	[illegible]
Ringwood	Passaic	.....	6.70	.....	1.90	[illegible]
RED SANDSTONE PLAIN.						
Paterson	Passaic	4.63	8.15	3.52	3.03	[illegible]
Hanover	Morris	3.75	8.44	4.69	3.30	[illegible]
Rivervale	Bergen	4.89	7.53	2.64	1.60	[illegible]
Roseland	Essex	.....	6.90	.....	1.64	[illegible]
Newark	do	3.65	5.35	1.70	1.30	[illegible]
South Orange	do	4.22	5.69	1.47	1.64	[illegible]
New York City	New York	3.80	5.78	1.98	1.47	[illegible]
Plainfield	Union	3.96	7.65	3.69	1.72	[illegible]
Elizabeth	do	4.55	7.83	3.28	1.60	[illegible]
Average		4.26	6.85	2.60	1.89	[illegible]

The record of these stations show that during the month of February, 1902, the precipitation was heavy, and that the storms occurred on eight days of the month, namely, the 1st, 2nd, 17th, 21st, 24th, 25th, 26th, and the 28th. There was in various places an insignificant amount of rainfall on other days, but the total is so small in comparison with the precipitation for the month that it may be disregarded without introducing errors. In the following table the amount of rainfall is recorded at the various stations during the eight days mentioned.

y precipitation in inches in and adjoining the Passaic Valley in February, 1902.

	Day of month.							
	1.	2.	17.	21.	22.	25.	26.	28.
HIGHLAND REGION.								
er	(a)	0.73	0.90	(a)	2.80	(a)	0.90	1.60
ster	0.20	.65	.96	1.70	.20	0.40	.70	.40
rlotteburg	(a)	.62	.60	(a)	2.00	(a)	.98	2.65
gwood	.15	.70	.95	.45	1.90	.06	.54	1.81
ED SANDSTONE PLAIN.								
erson	.62	.61	1.10	3.03	.20	1.15	.05	1.39
ıover	.27	.77	.90	(a)	3.30	.75	.65	1.60
ervale	(a)	1.58	1.30	(a)	2.30	(a)	1.60	.75
ıeland	.10	.55	.74	1.64	1.20	.61	.81	1.25
wark	.12	.40	1.30	(a)	1.28	.55	.60	1.10
ıth Orange	(a)	.60	1.00	1.64	.20	.78	.30	1.13
w York City	.19	.54	.93	1.02	1.47	.19	.98	.42
ıinfield	.18	.61	1.72	1.21	1.33	.34	.88	1.35
izabeth	.36	.53	1.60	(a)	2.70	.60	.64	1.40
Average	.91	.68	1.08	.82	1.61	.45	.74	1.30

a Included in record for following day.

Examination of the two tables above set forth shows clearly, first, ıat the month of February, 1902, was characterized by heavy prepitation, which exceeded the normal, and at many stations to an ctraordinary degree; second, the precipitation occurred on eight ıys of the month, and by far the largest part of it on the 17th, 21st, 2d, 25th, 26th, and 28th. Closer examination will show that the preipitation at the stations within the Passaic Basin was heavier than t the stations outside of the same, and while the latter undoubtedly erved to steady the general average, they also make an actual reducion when computed with the former. Therefore there can be no uestion that the adoption of the general average for all the stations ıs a measure of the amount of precipitation in the Passaic Valley is afe and conservative.

Our interest chiefly centers upon the last twelve days of the month; hat is, from the 17th to the 28th, inclusive. During that period there was a fall of 6 inches over the whole basin. This average will not serve in any calculation of the relation of run-off to the rainfall during the flood, because of the fact that there were so wide differences in the amount of precipitation in places not widely distant from one another. The average of 6 inches over the whole basin is but an approximation and does not represent accurately the actual amount

of water precipitated, hence any estimation of the proportion of rainfall to run-off must be precarious and, in all probability, incorrect.

The character of this enormous precipitation as it fell is an important consideration. The heavy snow of the 17th, equivalent to [illegible] inches, had not melted to any extent by the 21st and 22d, when it was reenforced by a destructive sleet equivalent to 2.43 inches over the drainage area, and at some stations to over 3 inches. There was a general rise of temperature on the 23d and 24th, during which a small amount of snow was melted, and about the same temperature was maintained during the 25th and 26th, on which days the total precipitation was 1.19 inches. On the 28th there was a short but tremendous downfall, amounting to 1.22 inches, and at the end of this storm the snow of the 17th had practically all disappeared. This means that from the 23d to the 28th, or during six days, nearly 6 inches of water were heaped upon the Passaic Basin, the greater proportion of which fell or was released through the melting of snow during the last four days.

GAGE HEIGHTS.

A precipitation so great and so rapidly delivered over an area the surface of which was frozen could not fail to produce extraordinary results. We find that on the Upper Passaic River, at Chatham, the water began to rise on Thursday, February 27, reaching a maximum on the afternoon of Saturday, March 1. On the Whippany River at Whippany Village near the mouth, the water began to rise on Friday about noon and reached a maximum at 10 o'clock p. m. on the same day, falling almost immediately. On the Rockaway River at Boonton (see Pl. VII, *A*) occurred the highest water since February 6, 1902, when the recorded height was 6 feet above the crest of the Boonton dam. On the present occasion the rise of water began on the afternoon of Friday, February 28, and reached its highest point March 1 at 3 a. m., at 5.55 feet above the crest. For seven hours, beginning on February 28 at 8 p. m., the rise was 2 inches per hour. The appreciable decline in flood flow began Monday, March 3, and by March 4 the water had lowered to 1 foot over the dam crest.

At the feeder of the Morris Canal at Pompton Plains, below the junction of Pequanac, Wanaque, and Ramapo rivers, the following gage readings were reported by Mr. L. M. Le Fevre:

Height of water at feeder of Morris Canal.

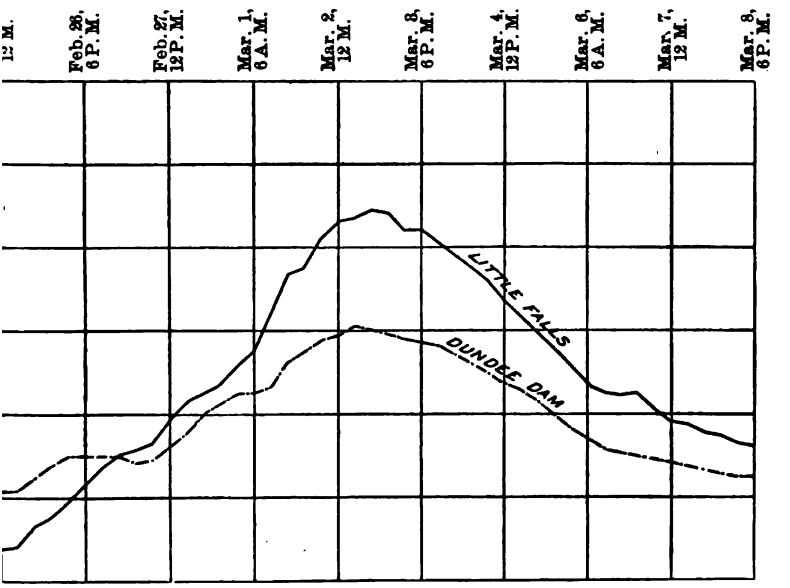
	Feet
February 28, 4 p. m	[illegible]
March 1, 6.10 a. m	[illegible]
March 2, 5.10 p. m	[illegible]
March 3, 2.30 p. m	[illegible]
March 4, 2.20 p. m	[illegible]
March 5, 7.40 a. m	[illegible]
March 6, 4.10 p. m	[illegible]
March 7, 6.50 a. m	[illegible]
March 8, 1.20 p. m	[illegible]

A. MEASUREMENT STATION AT STANLEY ON PASSAIC RIVER.

B. MEASUREMENT STATION AT WHIPPANY ON WHIPPANY RIVER.

ı the Ramapo River at Pompton Furnace the highest water was rved at 6 p. m. on March 1, where it reached 4.1 feet above the crest. The combined flow of the Wanaque and Pequanac rivers measured at the Van Ness farmhouse in Pompton Plains, and cated a beginning of rise on February 28 in the early afternoon, hing a maximum on March 1 shortly before noon. The high r was maintained fairly steady during March 1 and 2 and by ch 5 had retreated within its banks.

ıe great volume of water poured out upon the central basin raised evel to such a height at Two Bridges, the junction of the Passaic Pompton rivers, that the gages maintained there by the Division Iydrography were submerged and the water flowed around the ges and inundated the neighboring fields.



IG. 5.—Diagram of gage readings at Little Falls and Dundee dam during flood of 1902.

; Little Falls and at Dundee dam, just above Passaic, gage read- have been preserved and are diagrammatically shown in fig. 5. brief description of the two dams and the conditions surround- them will be desirable in connection with the consideration of 5. The Little Falls dam is constructed with two wings adjoining main dam, which occupies a transverse position across the center ıe stream. Fig. 6 shows the plan of the site to good advantage, le the general appearance during flood is faithfully represented in IV, *A*. The main dam is 160 feet in length, with an elevation of 18 above tide; the north wing is 64 feet long and has an elevation 57.81 feet, while the south wing, constructed parallel to the chan- is 61 feet long, the crest being at an elevation 157.56 feet above . The dam at Dundee is built of stone, the crest being 27 feet

above mean tide. It is 480 feet in length and has a width of 3 feet at the crest, holding back a pond of 224 acres. (See Pl. VII, *B*.)

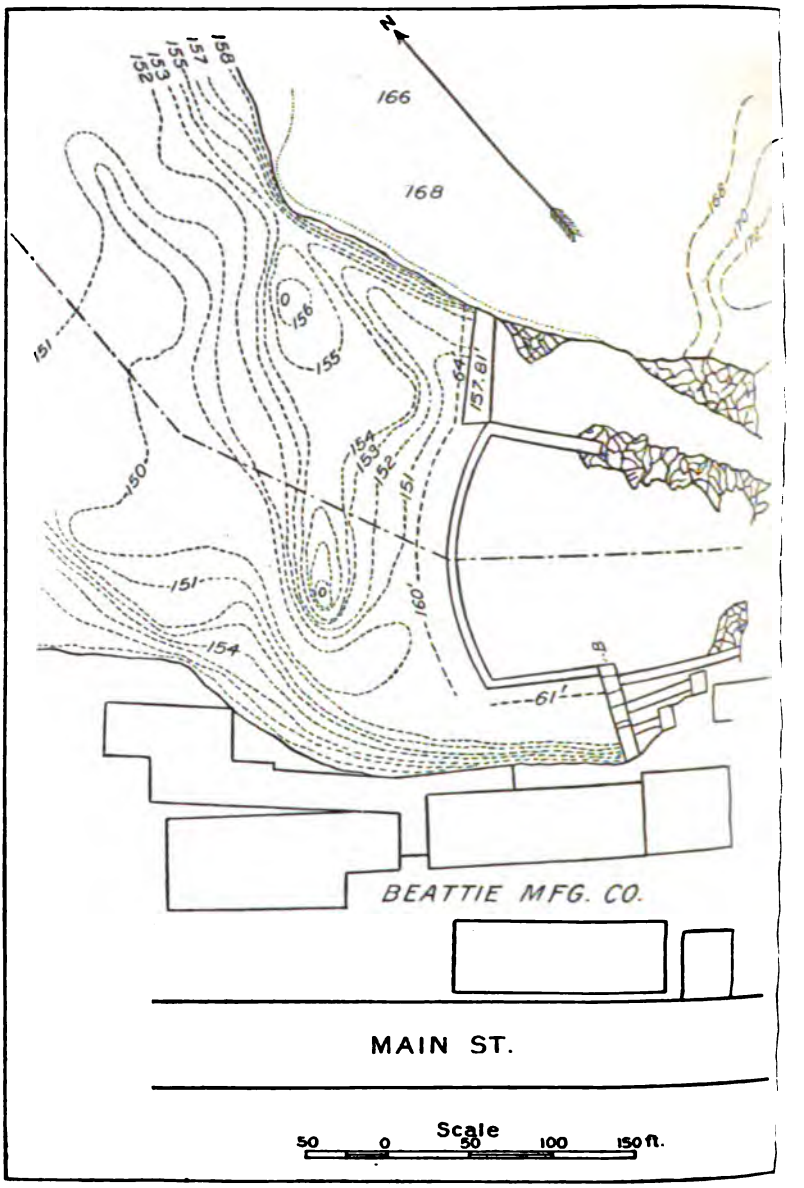


FIG. 6.—Plan of Beattie's dam, Little Falls.

FLOOD FLOW OF HIGHLAND TRIBUTARIES.

From the records of two series of current-meter measurements taken at different gage heights during the two weeks following the flood, and the marks made by eyewitnesses during the flood period,

ng tables have been constructed for each of the Highland tribu-es which seem to bear the test of reasonable analysis and to fur-ı valuable information concerning the discharge of the various ·ams. This discharge in second-feet for six-hour periods during flood—that is, from February 25 to March 9—is set forth in the le below.

rage flow in second-feet of Highland tributaries during six-hour periods, February 25 to March 9, 1902.

Date.	Time of day.	Upper Passaic.[a]	Whippany.	Rockaway.	Pequanac.	Wanaque.	Ramapo.	Total.
ruary 26	12- 6 a.m.	134	95	185	110	148	216	888
	6-12 a.m.	218	155	302	185	239	351	1,450
	12- 6 p.m.	379	270	520	322	416	573	2,480
	6-12 p.m.	523	372	725	444	574	842	3,480
ruary 27	12- 6 a.m.	560	430	800	500	650	850	3,710
	6-12 a.m.	590	490	850	650	745	865	4,190
	12- 6 p.m.	625	550	900	800	954	880	4,709
	6-12 p.m.	650	610	1,000	970	1,145	890	5,265
ruary 28	12- 6 a.m.	670	650	1,050	1,000	1,237	900	5,507
	6-12 a.m.	700	712	1,300	1,440	1,745	1,200	7,097
	12- 6 p.m.	728	846	1,436	1,660	2,300	1,700	8,670
	6-12 p.m.	875	1,071	1,636	2,225	2,600	3,100	11,507
rch 1	12- 6 a.m.	1,050	1,505	2,535	2,725	3,050	4,400	15,265
	6-12 a.m.	1,440	1,470	2,780	3,350	3,900	5,000	17,940
	12- 6 p.m.	1,630	1,430	2,780	3,900	3,900	5,150	18,700
	6-12 p.m.	1,630	1,380	2,780	4,215	3,900	5,225	19,130
arch 2	12- 6 a.m.	1,600	1,340	2,780	4,280	3,900	5,280	19,180
	6-12 a.m.	1,550	1,300	2,780	4,350	3,900	5,120	19,000
	12- 6 p.m.	1,500	1,260	2,780	4,330	3,525	4,000	17,395
	6-12 p.m.	1,440	1,220	2,780	4,050	3,075	3,450	16,015
arch 3	12- 6 a.m.	1,400	1,180	2,527	3,400	2,875	3,050	14,432
	6-12 a.m.	1,355	1,140	2,600	3,275	2,750	2,850	14,000
	12- 6 p.m.	1,310	1,100	2,645	3,150	2,675	2,780	13,660
	6-12 p.m.	1,250	1,000	2,565	3,050	2,490	2,790	13,205
larch 4	12- 6 a.m.	1,200	1,020	2,400	2,825	2,300	2,780	12,525
	6-12 a.m.	1,155	980	2,420	2,625	2,100	2,760	12,040
	12- 6 p.m.	1,090	940	2,360	2,400	1,900	2,720	11,410
	6-12 p.m.	1,045	900	2,295	2,200	1,725	2,620	10,785
larch 5	12- 6 a.m.	1,000	860	2,220	2,000	1,500	2,530	10,110
	6-12 a.m.	960	810	2,150	1,775	1,350	2,370	9,415
	12- 6 p.m.	905	760	2,085	1,600	1,245	2,250	8,845
	6-12 p.m.	845	710	2,015	1,440	1,150	2,120	8,280
March 6	12- 6 a.m.	800	660	1,940	1,330	1,060	1,960	7,750
	6-12 a.m.	750	610	1,870	1,240	1,000	1,810	7,280
	12- 6 p.m.	700	520	1,805	1,200	940	1,700	6,865
	6-12 p.m.	650	490	1,740	1,140	800	1,650	6,470
March 7	12- 6 a.m.	600	440	1,670	1,100	800	1,600	6,210
	6-12 a.m.	550	390	1,605	1,080	760	1,650	6,035
	12- 6 p.m.	500	340	1,535	1,065	750	1,600	5,790
	6-12 p.m.	450	300	1,465	1,055	785	1,620	5,675
March 8	12- 6 a.m.	400	260	1,400	1,050	780	1,660	5,550
	6-12 a.m.	350	210	1,335	1,050	811	1,700	5,456
	12- 6 p.m.	300	160	1,265	1,060	920	1,750	5,455
March 9	12- 6 a.m.	250	160	1,125	1,075	1,100	1,800	5,510

[a] At Chatham.

Total run-off, 8,960,248,000 cubic feet.

The measurement station established upon the Upper Passaic R[illegible] at the village of Stanley, near Chatham, is shown on Pl. VIII, [illegible] lies about 300 feet below the Stanley dam, which was carrie[illegible] during the flood. No appreciable overflow of the banks occurr[illegible] the results obtained by current-meter measurements are trustw[illegible] After the destruction of the dam the millrace carried no wat[illegible] there was therefore no necessity for taking the race discharg[illegible] account. The station established at Whippany Village, nea[illegible] mouth of Whippany River (Pl. VIII, *B*), is probably the least [illegible] factory of the Highland stations. During the height of the flo[illegible] water left the banks of the stream and overflowed the road for [illegible] hours. The time limits and the depth of water so overflowed [illegible] however, accurately observed and the measurements are suffic[illegible] trustworthy for the present purposes.

The station on the Rockaway River, about 2¼ miles below B[illegible] was established on a cross section of the channel, in the cente[illegible] which an island is situated, necessitating the measurement of [illegible] channels (see Pl. IX, *A*). The records obtained at this point d[illegible] include the entire flow of Rockaway drainage area, as the sta[illegible] about 7 miles above the watershed limits. A large part of this [illegible] however, is included in the wet lands described in the introdu[illegible] over which the water rose during the flood. This station, alth[illegible] serving fairly well in high water, is useless during dry seaso[illegible] it has since been abandoned.

The measurements upon the Pequanac River are more trustw[illegible] than those on any other highland tributary, because accurate g[illegible] readings were maintained by the water department of the city [illegible] Newark, at the Macopin dam during the entire flood period (see Pl. IX [illegible] *B*). This dam has been accurately rated by Mr. John R. Free[illegible] and the results of weir measurements can be depended upon. Addi[illegible]tional measurements were also made with the current meter at [illegible] New York, Susquehanna and Western Railroad bridge, a few m[illegible] above the mouth of the river. The combination of the two se[illegible] serve to give an approximately correct estimation of flow in [illegible] Pequanac River during the flood. In the table on page 37 the stat[illegible] flow of the Pequanac River embraces only that volume of water w[illegible] actually passed into the Pompton, and does not include the d[illegible] draught of 371 second-feet for the supply of the city of Newark [illegible] withdrawn at the Macopin intake.

A short distance above the mouth of the Wanaque the cha[illegible] forks, and the two divisions are crossed by a highway bridge [illegible] in two sections to conform with the channels (see Pl. X, *A* and *B*[illegible] The distribution of the flow of Wanaque River into two comparativ[illegible] wide channels gives shallow water even during floods, and the brok[illegible] uneven surface on the bottom renders good current-meter meas[illegible]ments somewhat hard to obtain.

A. MEASUREMENT STATION ON ROCKAWAY RIVER NEAR BOONTON.

B. MACOPIN DAM.

ie measurement station on the Ramapo was located near the th of the river on a highway bridge just below Pompton Falls VI, *A*). The channel here is deep and well defined, and the surements given in the table are trustworthy. The flow of water he raceway running from the head of Pompton Falls has been sured and proper allowance therefor has been made in the table. . study of the table on page 37 will show that in each of the High- d tributaries the rise of water during the flood was rapid and the st was not long sustained, recedence following almost as quickly the rise. The combined flow of the tributaries must, therefore, ring a short period, have been enormous, and it is readily inferred at a channel of great capacity would have been necessary in order to ry away immediately the waters delivered into the central basin. It s been stated, however, that the channel at Little Falls is a narrow e and is artificially constricted by the aqueduct of the Morris Canal, shown in Pl. VI, *B*. The area contributing to the flow of the High- nd tributaries is approximately 636.2 square miles, or 82.2 per cent the total area above Little Falls. The run-off from the remaining .8 per cent could not be measured and can be estimated only by king the proper proportion of the entire run-off of the area. Bear- ig this in mind, let us consider briefly the flow of water over Beattie's am at Little Falls, a plan of which is shown in fig. 6.

FLOOD FLOW AT LITTLE FALLS.

The rating table for Beattie's dam consists of three parts, which are djusted to conform with the conditions existing at the main dam and he north and south wings. Back of the main dam the river has been illed with stone to a considerable distance, affording a very gradual slope forward from the bottom of the stream to the crest of the dam, the grade being approximately 5 to 1. Bazin's series for wide-crested weirs was used in the flow calculations at this point, the coefficients which appeared to be most applicable being those determined in Cornell University Experiment No. 3, under the date of May 26, 1899. The north and south banks have vertical faces, the crest in each case being about 7 feet from the bottom of the stream. The series of Bazin most nearly conforming to these conditions is No. 114, developed for greater heads at Cornell University June 1, 1899, and denoted as Experiment No. 10.

Calculating the flow of water over Little Falls dam during the flood period, the results diagramatically represented in fig. 7 are secured.

Inspection of the accompanying diagram does not reveal any unusual characteristics. It is a conventional flow curve such as is usually found upon investigation of any flood. The rise of water is considerably sharper than the decline, and the height of the flood is maintained for a considerable period, arriving at an apex at noon on March 2. It will be noted that the flow curve is ended with the value for March 9 at 6 a. m. This is because a second rise in the waters took place

as a result of a storm which was entirely distinct from those w occasioned the flood under discussion. Pl. V, *A* and *B* shows cle

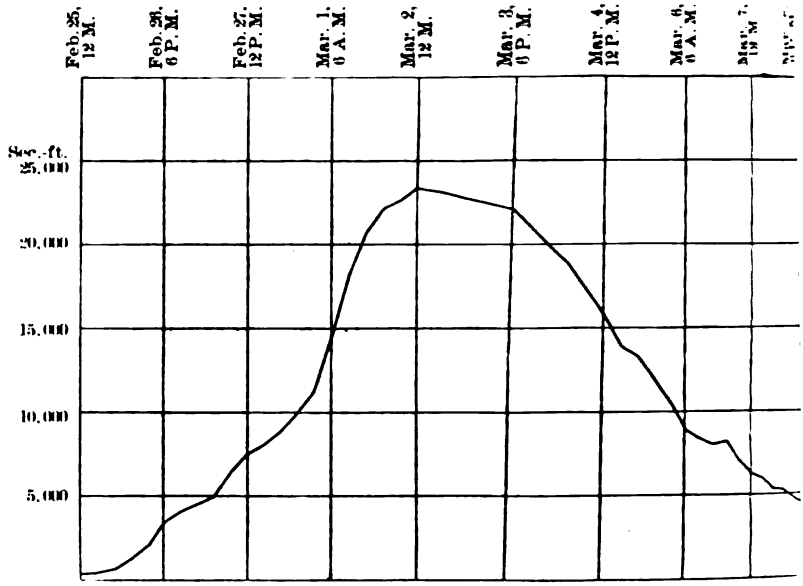


FIG. 7.—Flow of Passaic River over Beattie's dam at Little Falls February 25 to March

the comparative conditions existing in the gorge during low water an at the time of the flood under consideration. It will be seen that

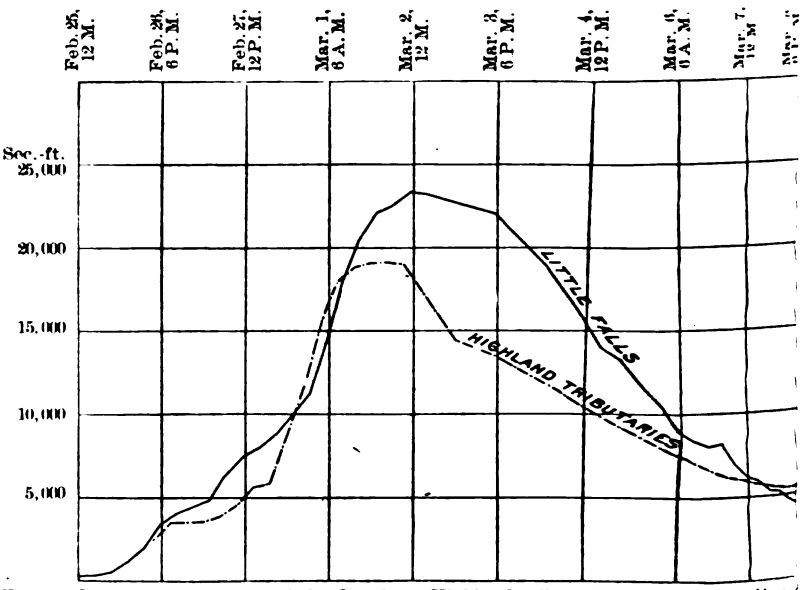


FIG. 8.—Comparative diagram of the flow from Highland tributaries into the central the Passaic and the flow from Beattie's dam at Little Falls.

rise here is considerably greater than over Beattie's dam, a short distance above, denoting a carrying capacity even less than the dam.

[aving now considered the flow of water from the Highland tribu-
ies into the central basin through Little Falls gorge during the flood
iod, it will be instructive to compare the two flow curves and show
relations, so far as possible, between the flow of the water into the
in on the one hand and the flow out on the other.

nspection of the table on page 37 indicates that the rush of water
m the Highland tributaries into the central basin during the crucial
t of the flood was greater than the flow of the river at Little Falls.
is condition is indicated from 3 p. m. on February 28 to 12 m. on
rch 1. It is clear that if, to this flow from Highland tributaries,
add the estimated run-off not represented in the Highland tribu-
y curve, the excess of water delivered upon the central basin dur-
g this short period, over that passed through the Little Falls gorge,
uld be still greater. It is interesting to note that the excess of
w at Little Falls indicated in the diagram, during the period between
o'clock noon on March 1 and 6 o'clock p. m. on March 7 is nearly
ual to the calculated flow from the central basin, the 17.8 per cent
the drainage area above Little Falls not represented in the High-
nd tributary curve. It should also be borne in mind that in the
ntral basin the precipitation causing this flood was heavier than
sewhere in the surrounding country,[a] and this would in a large
egree compensate for the excess which still appears after deducting
e calculated flow of the 17.8 per cent from the excess of the Little
alls readings over those of the combined Highland tributaries.

Considering fig. 8 as it stands, however, it gives clear testimony
hat until a certain height of water was raised over the central basin,
ducing, of course, a heavy pressure upon the outlet at Little Falls,
he gorge did not carry anything like the amount which was subse-
uently observed to be flowing over Beattie's dam.

ENERAL FLOOD-FLOW STATISTICS IN HIGHLAND TRIBUTARIES.

In the table below are given the general flood-flow statistics in
Highland tributaries:

General flood flow in Highland tributaries.

Measurement station.	Contributing drainage area.	Percentage of contributing area to total above Little Falls.	Total run-off for each station.	Run-off per square mile.	Run-off in inches on watershed.
	Sq. miles.		*Cubic feet.*	*Cubic feet.*	
Passaic, at Chatham	99.8	12.9	825,847,200	8,275,022	3.5
Whippany, at Whippany	55.9	7.6	716,364,000	12,281,510	5.5
Rockaway, below Boonton	125.4	16.6	1,737,841,600	13,850,411	5.9
Pequanac, below Bloomingdale	84.8	10.9	1,829,352,600	21,572,240	9.3
Wanaque, at Pompton	109.6	14.2	1,645,251,400	15,011,411	5.8
Ramapo, at Pompton Lake	160.7	20.8	2,205,619,200	13,725,073	5.9

[a] See table on p. 32

SUBMERGED LANDS IN CENTRAL BASIN.

Among the notable features of the flood were the effects of the rise of water into the central basin, the submerged area, 32,000 acres, being of unusual extent. It will be observed by inspection of the shaded portions of Pl. XI that the impounded waters were divided into two distinct areas. The widely extended and irregular tract embracing what is known as the Great Piece Meadow, Troy, Black and Long meadows, Hatfield Swamp, and the Bog and Vly meadows has an area of 22,746 acres, while the Great Swamp, situated farther to the south and divided from the former accumulation of water by the terminal moraine, has an area of 9,376 acres. There is little question that the flooded area shown on Pl. XI was not entirely covered at one time. The water first collected in the upper

FIG. 9.—Flow of Passaic River over Dundee dam February 26 to March 9, 1902.

portions of the swamp land, and there was considerable slope toward the outlet at Little Falls. In the latter stages of the flood there was a greater area of submerged land near the outlet, while there had been a noticeable recedence above. The flooded lands will be further discussed under the section dealing with damages caused by the flood.

The point of flow measurement next below Little Falls is at Dundee dam, a diagrammatic representation of the gage heights of which was given in fig. 9. The dam has already been partly described. It extends directly across the bed of the stream, and the upper and lower faces slope from the crest. On the upper face of the dam there is a fairly uniform grade of 2–1 to the river bottom, while on the lower face the dam is built up of sixteen consecutive steps, with 1-foot

A. GAGING STATION NO. 1 ON WANAQUE RIVER AT POMPTON.

B. GAGING STATION NO. 2 ON WANAQUE RIVER AT POMPTON.

rs and 1-foot treads. This gives a slope of 1-1, but on account of deterring effect of the steps during flood flow the coefficient to applied in determining the volume of water passing over the dam st necessarily conform to that determined for a batter of gentler pe. The coefficients selected were those promulgated in Cornell iversity Experiment No. 8, dated May 30, 1899, which is an adaptan of the Bazin series No. 78 for greater heads. Fig. 9 shows diammatically the flow over Dundee dam during the flood of 1902.

FLOOD FLOW AT DUNDEE DAM.

Examination of the above flow curve reveals that there are peculiities in the rise of the flood not noted in the flow curve for Beat's dam, namely, two decided checks in the progress of the flood. om the examination of similar curves for previous floods over this

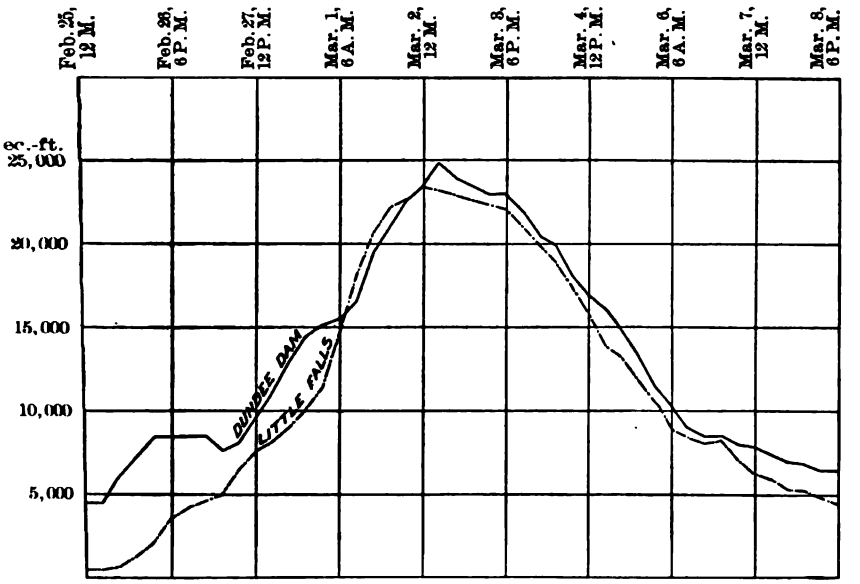


FIG. 10.—Flood flow curves over Beattie's and Dundee dams showing relations.

dam, checks of this nature appear to be a characteristic feature, the cause of which has not been definitely determined. It has been suggested that the decrease in the flow in former floods has been caused by the onrush of water from Pompton River which, as has been explained, flows into the central basin with the combined discharge of the Ramapo, Wanaque, and Pequanac rivers from steep grades, thus delivering its waters before those of the more sluggish Passaic can descend its sinuous course, and that when the force of the flood in the Pompton expends itself there is a temporary check in the progress of the rise of waters below. However true this may be in the case of other floods, it certainly does not apply in this instance. There is no evidence from the examination of the flow curve at Little Falls that any such phenomenon occurred, and what is more convinc-

ing, the check took place nearly two days before the flow from the Pompton River had reached its maximum. It is extremely probable that these peculiarities in the rise of the flood are the result of the run-off from the area between Little Falls and Dundee dam. It is naturally a quick-spilling area, having been divested of forests and containing a comparatively large expanse of macadamized roads and paved streets. The large city of Paterson and the surrounding area empties its entire run-off into the Passaic, and this in itself would have some effect upon the rate of increase after great precipitation.

Comparison of the flow curves in fig. 10 seems to support the contention advanced concerning the cause of the temporary checks in the progress of the flood curve over Dundee dam. It is expected that the increase in the flow over Little Falls dam would be a practically constant one because of the steadying effect of the great storage afforded by the meadow lands, and the steady rise in the Little Falls curve bears out this idea. The Dundee curve, on the other hand, shows at the beginning every indication of a flashy, quick-spilling contributing area, the effects of which are not overcome until the flood has advanced to within one day of its maximum. At that time the steady pressure from Little Falls seems to give more character to the Dundee curve and the remainder of the diagram is conventional. It will be noted that the apex of the Little Falls curve falls twelve hours before that of Dundee dam, which is about the time which might be expected to ensue when we consider the comparatively large storage capacity afforded by Dundee Lake.

FLOOD BELOW DUNDEE DAM.

The action of the flood waters below Dundee dam was sufficiently different from those in the valley above this point to warrant special mention.

The physical character of the valley from the dam to the mouth of the river is strikingly different from that of its other sections. As has been stated, it consists of, first, a short reach of 4 miles through the city of Passaic, with a total drop of 6 feet. At this point the river turns sharply and returns to its former direction in a broad S-shaped bend. This peculiar bend is significant in connection with the supposed change of the stream's course during Glacial time. It also has a bearing on flood conditions in that it lies in a flat basin-like widening of the valley, and high waters, especially such as come with much force, are forced to leave the channel and invade the surrounding low-lying territory. The second distinguishing feature is that below this point the river becomes a tidal estuary 13½ miles in length, and lies in a constricted valley which becomes narrower as the mouth of the river is approached. At Passaic, Belleville, and Newark docks have been constructed, which still further decrease the natural width of the channel, and in addition to them a number of railway and

A. DAM ON PEQUANAC RIVER NEAR POMPTON.

B. SUBMERGED FLAT LANDS AT SINGAC.

ıway bridges have been built across the stream, which by piers abutments more or less obstruct the flow.

ı this section of the valley population is dense, and with the single eption of the low-lying portion of the city of Paterson manufac- ıng and other interests are more seriously affected by high water n elsewhere upon the watershed.

'he waters of the lower river fairly followed the gage heights at ndee dam during the first part of the flood. On February 27 the ers were high; on the 28th they had arisen above the right bank Passaic bridge and flooded the highway at this point. On March 1 flats situated above Wallington and the areas adjacent to the er on both sides for several miles below were flooded. On this and following day water rose above the floors of the highway bridges Passaic, Rutherford, Avendale, and Belleville, and these bridges re in great danger of being carried away, while the bridge at Pas- ıc, just below Dundee dam, was lifted from its foundations and mpletely wrecked (Pl. XV, *B.*) This danger was much increased by e amount of débris, especially in the form of driftwood from lumber ırds, which became lodged against the piers and bridge spans. The ie Railroad bridge at Passaic was threatened and trainloads of avy iron and coal were placed upon it to add to its stability. On arch 3 and the days following the waters gradually subsided until ıe normal stage was resumed.

FLOOD FLOW OF SADDLE RIVER.

In connection with the flood in the lower valley should be consid- red the discharge of the Saddle River, which enters the Passaic just pposite the city of that name. Although this stream joins the main runk below the dam at Dundee, where one of the main flow compu- ations was made, and though its volume was not included in the ischarge curves given above, it still seemed to have an influence in swelling the volume of the waters near Passaic and Wallington and ncreasing the damage done at these points.

From evidence secured at Boetger Piece Dye Works at Lodi, the Saddle River began to rise on Friday, February 28, at about 6 p. m. It rose steadily until Saturday morning, March 1, between 2 and 3 o'clock, remaining high until 7 a. m. of the same day. By 5 o'clock p. m. on Saturday, March 1, the waters had receded within their banks, and gradually declined in volume for the next five or six days.

No measurement was made of its flood discharge, but on April 12, 1902, a current-meter measurement showed 221 second-feet flowing at Lodi, the water at the time of the flood being 7.6 feet higher than at the time of the measurement.

The flood on this river closely resembled previous floods in rising and retiring quickly, and the crest of its flood wave reached the main stream before the waters from the other tributaries entered the lower valley.

Although the flood crest of Saddle River did not play an important

part in the flood on the main stream, its subsequent discharge, [illegible] larger than usual, coming in conjunction with the rising waters of [illegible] main stream, must have had its effect in increasing the damage in [illegible] Wallington-Passaic district.

At Passaic Bridge near the southern extremity of the flat extent of the valley just mentioned the main line of the Erie railroad [illegible] the flats on an elevated embankment and passes over the river [illegible] drawbridge. This bridge has two piers in the river, as shown on [illegible] I, *A*. Each of these piers is surrounded by piling which in time [illegible] high water catches much floating débris and acts as a temporary obstruction to the current. The distance from the abutment on [illegible] right bank to the main pier, that which supports the draw, is [illegible] and from the main pier to the abutment on the left bank, 81.5 [illegible] West of the main abutment, as seen on the left of Pl. I, *A*, a [illegible] way passes beneath the elevated tracks through a masonry culvert [illegible] feet wide at the base. The entire discharge from the watershed of over a thousand square miles is obliged to pass through these openings which have a total width of 350.5 feet, and which in very high water are more or less contracted by the lodgment of débris against the piers. During the flood under discussion the water rose over the roadway shown on the left of Pl. I, *A*, and stood for some time above the level of the stone walls seen on the extreme left. The high-water mark on the bridge itself was about half way up on the middle [illegible] of the draw plainly seen above the piling in the picture.

HIGH-WATER MARKS IN LOWER VALLEY.

By the courtesy of Mr. Robert M. Watson, of Wise & Watson, engineers, of Passaic, N. J., we are permitted to use the following levels taken at the time of high water at different points from Passaic to Belleville:

High-water marks in lower valley.

[Elevations given are reduced to the State's datum.]

	Elevation in feet
At Enameline's Works, southerly corner of Seventh and Worthen streets (Dundee district), in city of Passaic, near right bank Passaic River	[illegible]
In engine room Passaic Lumber Company's mill, northerly corner Lester and Scott streets, in borough of Wallington, Bergen County, N. J.	[illegible]
On northwesterly fence Standard Bleachery property, at a point about 300 feet northeast of Erie Railroad at Carlton Hill, Bergen County, N. J.	[illegible]
On office building of Anderson Lumber Company, on right bank Passaic River, near foot of Gregory avenue, in the city of Passaic (and on River Road)	14.[illegible]
On entrance to Pagoda Hotel, near right bank of Passaic River on River Road, and about 150 feet southwest of Erie Railroad bridge across Passaic River, in the city of Passaic	[illegible]
On northwesterly corner piazza E. T. Galloway's house, at easterly corner River Road and Woodward avenue, in the borough of Rutherford, Bergen County, N. J	[illegible]
On Powell's front stoop, south side of Rutherford avenue, about 500 feet southeast of Passaic River	11.[illegible]

A. FLOODED AREA ON GREAT PIERCE MEADOWS.

B. FLOOD AT TWO BRIDGES.

	Elevation in feet.
;round at carriage entrance to William R. Traviss's estate, on Valley ›ok avenue, near southerly corner Valley Brook and Park avenues and ver Road, at Lyndhurst, Bergen County, N. J	11.00
ıt three inches higher than wheel guard on Avondale bridge across ssaic River, between Essex and Bergen counties	10.31
hwesterly pier Belleville bridge across Passaic River, between Essex l Bergen counties	9.21

·om these a profile of the flood t has been drawn and is also ıded (fig. 11). In the profile the ·y base line represents the ordi- ' mean water level of this part he river, while the flood crest is ·esented by the irregular line ·e; at each point where levels e taken profiles of cross sections he valley have been inserted to ·w the extent to which waters ·flowed the banks.

striking feature, not brought by this diagram, is found in nection with the levels at the ıdard Bleachery and at Passaic lge, just above and below the ; Railroad bridge. The Stand- Bleachery is located on the north › of the Erie Railway embank- ıt (about one-third of a mile k from the stream at Passaic lge), and at the eastern edge the flat area on the left bank ;he river on which also stands borough of Wallington. The achery level was 15.98 feet, while t on the north side of the bridge ; about 14.65 feet, as taken from eful levels a few days after waters had subsided. It has ›n suggested that the high level the Standard Bleachery, which ms to be well authenticated, y have been due to the onrush the waters of the main stream ;ether with the heavy discharge Saddle River, which forced the ters over the Wallington flats d temporarily piled it up against the obstructed embankment and ; rising land near which the Bleachery is situated.

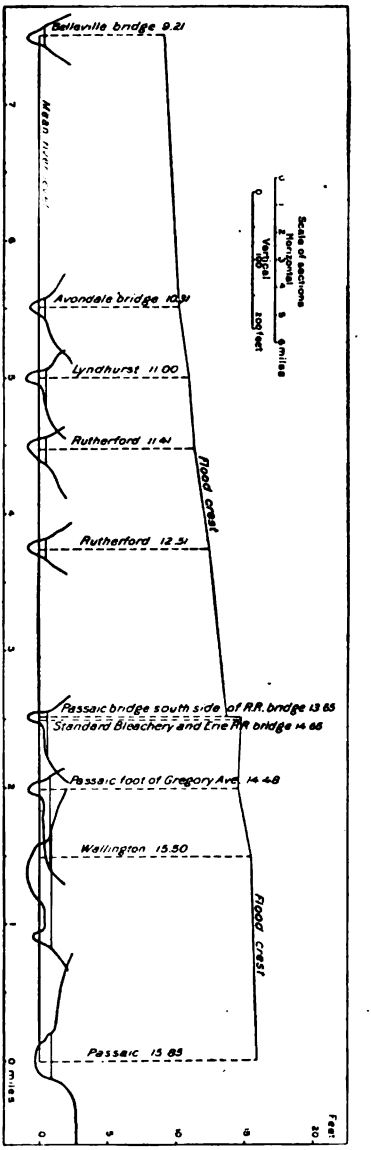


FIG. 11.—Profile of flood crest, Passaic to Belleville.

The next level was taken at Passaic Bridge, but a few feet [illegible] the Erie bridge and embankment. This level was recorded as [illegible] feet, a difference between that on the north side of the brid[illegible] about 1 foot (see fig. 11). Eyewitnesses on the ground at the ti[illegible] the flood testified that there was a striking difference in the heig[illegible] the water on the north and south sides of the Erie abutments [illegible] that the water poured between them as over a sloping bed.

The various section profiles of the valley accompanying fig. 1[illegible] again the gradual narrowing of the valley which was before re[illegible] to in the general discussion of the river, and was there attrib[illegible] to the possible change of drainage which has taken place in pa[illegible] geologic times.

LOSSES CAUSED BY THE FLOOD.

Floods of such magnitude as the one under discussion must [illegible] necessity cause great damage, but from the varying nature of the losses and the circumstances surrounding them it is impossible to make more than an approximation of their amount.

As might be expected, the losses were greater in the central basin and lower valley than on the tributaries in the Highland area. I[illegible] the last-named section, the proportion of population being small [illegible] few industries centering upon the rivers, there was little opportunity for extensive damage. The valleys are so narrow and steep-[illegible] that there was comparatively little flooding of highways and valley floors. One or two dams were carried away, notably that at Pompton on the Pequanac (Pl. XII, *A*), and some of the highways in the mountain valleys were flooded.

In the central basin the losses were much greater, being occasioned by extensive flooding of farm lands (see Pl. XIV, *A* and *B*) involving considerable damage to stock and personal property. In many instances cattle and horses had to be removed to places of safety and suffered much from exposure. Barns, cellars, and houses were flooded (see Pls. XII, *B*, and XIII, *B*) and the inmates were confined by the waters. The damage was furthermore much exaggerated by the unusual duration of the flood, the waters remaining on the farm lands of the basin for more than a week.

Three railroad lines cross this portion of the Passaic watershed—the Morris and Essex and Boonton branches of the Delaware, Lackawanna and Western Railroad and the Greenwood Lake Branch of the Erie Railroad. The first two lines traverse the basin for the most part at altitudes higher than the level of the flooded area; but the Greenwood Lake Branch runs for several miles over a section of the flat lands and was much affected by the flood conditions. The tracks of this road were flooded above Singac, also at Mountainview and below Pompton Plains. The water reached the ties of its bridge across the Passaic at Signac and the structure was only held in place

A. FLOODED FARMHOUSE IN CENTRAL BASIN.

B. FLOODED FARM LANDS IN CENTRAL BASIN.

ains heavily loaded with iron and coal. Just above this point rack was washed over by the overflow from the left bank of the and large portions of its gravel embankment were carried away. unately there are no large towns located in the flooded lands of upper basin, or the damage to individual property holders would been much more serious.

addition to the injury to private property the chief damage in part of the drainage area consisted in that sustained by the lges from débris and floating ice, the complete suspension of travel the flooding of highways, and the loss and inconvenience due to interruption of travel upon the railroad lines.

ome of the highways were passable with difficulty, but many of se most used, especially such as run near the main stream, were ssed in many places by swift currents of water from 3 to 6 feet in pth, through which passage was impossible except for the most avily loaded wagons.

The total area of the flooded lands, as seen by reference to the map the central basin, Pl. XI and various plates of the report, was proximately 32,000 acres. A number of dams were carried away the tributaries near the edges of the central basin, notably that the Passaic proper at Stanley. Fortunately the water confined by ese structures was not enough in amount to seriously damage the wer portions of the valley below Little Falls, and from that point to e mouth of the river the damage was of a different character.

As has been described, the valley below Little Falls is comparavely narrow and thickly populated, Paterson, Passaic, and the interening towns being closely built up to its banks. Between Paterson nd Little Falls the roads on both sides of the stream were flooded, and he trolley line—much used by employees of factories at Little Falls ho reside at Paterson and depend upon the line for transportation—as completely blocked for several days. The pumping station of the East Jersey Water Company, located at the foot of the main drop at Little Falls, was considerably damaged by the rise of waters, which looded its main floor to a depth of several feet, stopping all operations and injuring the pumps and electric motors which were there installed. Pl. VI, *B*, shows the water standing at a higher level than the floor of the pumping station as seen looking downstream under the viaduct of the Morris Canal.

Below the main falls in Paterson the city closely confines the river on both banks. The left bank stretches back some distance from the stream as a low bench, which is built up with residences. This section was flooded for several blocks and remained under water a number of days. Many houses were damaged by the water, and while the individual losses were not heavy, they still amounted to considerable in the aggregate. On the right bank of the river the section extending several blocks east of River street was under water. This

is a business portion of the city and considerable injury to the [illegible] of the section resulted.

Below the Great Falls there are five bridges, some of which [illegible] damaged by ice and floating débris. In attempting to cross one [illegible] them, over which the water was flowing with great force, a horse [illegible] wagon was swept away and one man drowned.

Farther down the river heavy losses were sustained in the city [illegible] Passaic. This town stands on the right bank of the river, and [illegible] several blocks back from the stream the land lies but a few feet above the ordinary river level. Here are located many factories and mills together with a large factory population. The waters rose so rapidly onto this bench that it was impossible for the owners to remove valuable goods from the floors of their storehouses, and in consequence the losses were very large. It is estimated that the mill owners [illegible] Passaic were losers to the amount of $600,000, and that there were personal losses from residents of the district of $200,000 more. Upward of 400 small shops are reported to have been flooded, the resulting loss to whose owners can not be estimated, for it consisted not only in damage done to stock but damage entailed from the length of time necessary to resume business.

In and below Passaic there are situated a number of lumber yards on the banks of the stream. Most of the stock there located was carried away, and some of it was lodged against the piers and framework of bridges below, making an additional cause of danger to these structures, and in the case of the county bridge at Passaic, throwing it completely out of position and rendering extensive repairs necessary. A large amount of lumber became lodged among the piles driven in front of the stone pier which supports the draw of the Erie Railroad bridge at Passaic. This accumulation so blocked the passage of the water between the abutments of the bridge that it may have been to some extent the cause of the difference of levels noted at this point.

On the other side of the river and opposite the city of Passaic is located a considerable settlement known as Wallington. This town also stands on a low river bench which marked a former bed of the stream. With the advancing waters the town was almost completely flooded, as shown by Pl. XV, *A*, and a damage of not less than $2[illegible] was sustained by the inhabitants. The foundations of the buildings, especially those of brick, seemed to have been undermined by the current which swept around them, and the buildings were, in some instances, thrown out of plumb. Altogether, the damage in the neighborhood of Passaic could not have been less than $1,000,000, and probably reached a much higher figure.

Along the lower course of the river to its mouth the immediate valley was flooded, but as the valley is much narrower in this portion than above and has no settlements to compare in size with Passaic

A. WALLINGTON DURING FLOOD.

B. FAILURE OF BRIDGE AT PASSAIC.

Paterson, with the exception of the city of Newark, no great nage was done, though much inconvenience and several cases of ere personal loss resulted.

t is estimated that the value of the bridges which were swept away the flood (Pl. XV, *B*) in various portions of the watershed ounts to not less than $300,000, in addition to the losses noted ove.

COMPARISON WITH PREVIOUS FLOODS.

It will be of interest to compare the flood of 1902 in the Passaic alley with those of other years. Previous to 1902 the greatest flood the Passaic River for a century, at least, occurred in September, 82. Mr. C. C. Vermeule, in the Report of the Geological Survey of ew Jersey, Vol. IV, reports concerning this flood as follows:

The flood of 1882 was probably the highest of this century, consequently more ood marks are preserved and a better recollection prevails of this than of other oods. By inquiry and comparison of data of other floods which I have obtained have been able to construct a fairly accurate history of this flood. The waters egan to rise at Dundee and Little Falls in the afternoon of the 22d, and rose teadily for 33 hours, when they reached 16,049 cubic feet per second. They then ell off for about 10 hours to 13,000 cubic feet per second, and then rose until they eached a maximum 66 hours after the beginning of the rise of 18,265 cubic feet er second at Dundee and 19,100 cubic feet at Little Falls. The upper branches ppear to have discharged their flood waters into the central valley within 72 ours, and to have subsided within their banks. They reached their maximum lischarge in from 20 to 40 hours after the beginning of the rise on the Passaic. In the following tables the maximum flows are obtained from well-defined flood marks at dams. The total discharge is estimated to be 3.13 inches on the shed, as already determined.

Below are appended the leading facts regarding the flood of 1902, and also regarding previous recorded floods, which will serve as an interesting basis of comparison.

Comparative statements concerning Passaic floods, measured at Dundee dam.

[Drainage area, 822.7 square miles.]

Date of flood.	Duration of flood.	Duration of rise.	Maximum flow.	Duration of fall.	Run-off: Inches on drainage area.
	Days.	*Days.*	*Sec.-feet.*	*Days.*	*Inches.*
February 25 to March 9, 1902	[a] 12	5.00	[a] 24,800	[a] 7.00	7.1
September 25, 1882 [b]	8	2.75	18,265	5.25	3.71
December 12, 1878 [b]	8	2.50	16,592	5.50	3.47
February 14, 1886 [b]	8	2.50	12,452	5.50	3.00
January 3, 1888 [b]	8	2.80	11,880	5.20	2.77
January 24, 1891 [b]	8	2.50	11,701	5.50	2.56
March 14, 1893 [b]	9	2.90	11,245	6.10	3.56
May 6, 1893 [b]	8	3.00	11,155	5.00	2.77
September 21, 1888 [b]	8	2.75	11,126	5.25	2.89

[a] Estimated. [b] From Report of New Jersey Geological Survey, Part III, 1894.

SUMMARY.

From the foregoing discussion it is seen that the Passaic R is of importance, both on account of the large manufacturing ests which depend upon it to a certain extent for power, an account of the cities which use it as a source of municipal w supply.

The Passaic drainage basin is peculiar in respect to its phys features. Unlike the ordinary habit of river systems, in which tributaries join the main trunk at intervals on either side, resemb the veins of a leaf, the important tributaries of the Passaic deli their waters to the main stream at points not far from the middl its course. They, moreover, flow from a mountainous region with ra fall, and meet the main artery in a flat, basin-like area which ea becomes flooded at even ordinarily high stages of the stream. It h been seen that the outlet to this basin is a narrow gorge at Litt Falls, restricted at its lower end by a masonry viaduct, and that times of very high water the gorge is too small to accomodate the d charge of the river, and extensive flooding of the basin above resul It has been observed that the low-lying portions of Paterson, Pass and the neighboring towns on the banks of the river in its lower co are subject to overflow during high freshets, which damage not o individual householders, but also the large manufacturing inter there located. The striking physical relations of the lower va have also been touched upon, namely, that there is a gradual narro ing of the valley as the mouth is approached, which seems to ha congested the outlet of flood waters in this portion of the drainag area.

With regard to the conditions preceding and accompanying th flood of 1902, it has been observed that during the latter part of Fe ruary of that year approximately 6 inches of precipitation, compo of melted snow, sleet, and rain, were released upon the frozen drai age area, and that much of this water passed rapidly into the strea

It was also seen that the mountain tributaries discharged lar volumes into the central basin, flooding approximately 32,000 ac of its area and doing considerable damage to farming and railro interests there located.

As indicated from gage heights, the rise of water began at Dunde dam about 6 p. m. on February 25, and, after subsiding slightly o February 26 and 28, reached its maximum of approximately 24,0 second-feet on March 2. The flow curve of the flood over Little Fa dam was quite similar to that at Dundee dam, the apex of the form occurring a few hours before that of the latter.

In regard to the damage done by the flood, the most general es mates only can be made, but in Passaic and vicinity, the section wh probably suffered most severely, $1,000,000 is thought to be a sma approximation of the losses sustained.

CONCLUSIONS.

loods on the Passaic drainage basin have not been so frequent so destructive hitherto as to warrant careful study with a view ither prevention or control, but as property along the banks of stream becomes more valuable for manufacturing and munici- purposes, and as population increases, the time may soon come n it will be necessary to consider seriously the habits of the saic's flood waters.

owing to the great demand already being made upon the basin for nicipal supply, the future will doubtless see a much better control n at present of the river's waters by storage reservoirs. But, ess great care is taken to keep the reservoirs low at such times of year as floods are likely to occur, much the same conditions may st in winter seasons as were found during the flood under discus- n. At that time all the lakes and reservoirs on the watershed were l, and the surface of the ground was rendered so impervious by st that when the excessive precipitation came it literally slid off area and over the reservoirs without check. The discharge tables d fluviographs show not only great irregularity in the flow of the eam, but the occurrence of freshet waters at almost any time of e year. For example, excessive high water occurred in the last eek of August, 1901, at which time it would have been considered wise to have allowed the supply reservoirs to run low.

There is one way, however, in which control could probably be had er the severest floods likely to occur on the drainage area, namely, y the construction of a dam across the Pompton at Mountain View, etween the eastern extremity of Hook Mountain and the continua- on of the same ridge east of that stream at the above-named place. y this means the waters of the Ramapo, Wanaque, and Pequanac vers united in the Pompton, draining approximately one-half the otal area of the entire catchment basin, could be controlled. The alue of such a dam for municipal supply has been pointed out by the tate engineer[a] and others. It has been estimated that a dam 2,200 eet long and 57 feet high would flood the flat basin in the neighbor- ood of Pompton Plains, well illustrated in Pl. XI, which includes an rea of about 18 square miles. It would be practicable to build the lam even somewhat higher, and thus secure a greater capacity for he reservoir. Such a dam would not only give sufficient storage apacity to regulate excessive floods, but would be of great advan- tage to those portions of the valley below Paterson, which are threat- ened by high waters. It would at the same time relieve the central basin by holding back a portion of floods until the waters from the remainder of the drainage area, approximately one-half of the total area, could escape through the gorge at Little Falls without seriously flooding the wet lands above that point.

[a] Ann. Rept. New Jersey Geol. Survey, 1894.

While the construction of such a reservoir is possible fr engineering standpoint, as the foundations and other features dam site are good, it would involve considerable expense in re tating a new alignment of portions of the two railroads which tr the region, namely, the Boonton Branch of the Delaware, La wanna and Western, and the Greenwood Lake Branch of the E and in addition the condemnation of a considerable amount of v and farm property in and around Pompton Plains. In view of expensive nature of these proceedings, there is slight probability such a dam will ever be built, but its construction would, with question, forever prevent the danger of heavy losses at points lower valley.

Destructive freshets may, therefore, be expected to occur o watershed at intervals separated by an undetermined number of ye which without elaborate and expensive engineering works can ha be fully controlled.

Although it may be impossible to satisfactorily control the waters, the danger from injury by them may be much reduced employing some means of systematic warnings of their approach.

This could be done by establishing gaging stations on the tributa near their junction with the main stream, where daily observations water heights could be taken. In times of excessively high wa the conditions at the various stations could then be telephoned some central point, such as the office of the engineer of the S for the Establishment of Useful Manufactures, who would compil the returns from the various tributaries, and if necessary give wa ing to manufacturers and others in the cities of Paterson and Pass of the approach of dangerous flood conditions, thus allowing the several hours to remove valuable material from warehouses befo the water reached the danger point.

INDEX.

Page.

.s's dam, flow over, diagram showing 40, 43
an of 36
See also Little Falls.
ton, measurement station near, view of 38
.se of water at 34
tockaway River at, view of 30
ton Hill, high-water mark at 46
.ral basin, area, topography, geology, etc., of 11–13
lat areas in 18
lood losses in 48–51
flooded area in, map of ..... In pocket
view of 12
flooded lands in, view of 48
submerged lands in 42
.rlotteburg, rainfall at 32, 33
.tham, rise of water at 34
.ster, rainfall at 32, 33
fton, Passaic Valley at, cross section of 14
ok, J. H., acknowledgments to 9
lawanna, Passaic Valley at, cross section of 14
.ver, rainfall at 32, 33
.ndee, Passaic River at, flow of 20
andee dam, description of 35–36
flood flow at and below 43–45
floods at, comparison of 51
flow of Passaic River over, diagram showing 42–43
gage readings at, diagram of 35
length and height of 13
view of 30
lizabeth, rainfall at 32, 33
airfield, flooded area near, view of 12
lood crest, profile of 47
looded area, map of ..... In pocket
view of 12
loods, comparison of 51
reat Falls. *See* Passaic Falls.
reat Pierce Meadows, flooded area on, view of 46
reenwood Lake, position, area, and altitude of 16
Hanover, rainfall at 32, 33
Highland area, extent, topography, soil, etc., of 10–11
Highland tributaries, flood flow of 36 39, 41
Little Falls, dam at, description of 35
dam at, plan of 36
view of 16
fall at 12

Page.

Little Falls, flood flow at 39–41
flow at, diagram showing 40, 43
gage readings at, diagram of 35
gorge at, views of 20, 24
water taken from river at 13
Losses, enumeration of 48–51
Lower Valley, area, topography, etc., of 13–15
high-water marks in 46–47
Macopin dam, view of 38
Mahwah, Ramapo River at, flow of 27
Morris Canal, height of water in feeder of 34
Morris Canal viaduct, Little Falls gorge at, view of 24
New York City, rainfall at 32, 33
Newark, Passaic Valley at, cross section of 14
rainfall at 32, 33
Newell, F. H., letter of transmittal by 7
North Newark, Passaic Valley at, cross section of 14
Old Boonton, Rockaway River at, flow of 27
Passaic, bridge at, view of wreck of 50
high-water mark at 46
losses at 50
Passaic Bridge, railroad bridge at, view of 9
Passaic Falls, fall at 12
view of 9, 16
Passaic River, course and character of 17
drainage area of, map of 10
drainage area, length, fall and gradient of 19
flow of 19–30
measurement station on, view of 34
profile of 18
tributaries of, descriptions of 15–19
Passaic Valley, cross sections of 14
description of 9–15
precipitation in 31–34
wet lands in 12
Paterson, damage at 49
Passaic Falls at, view of 9, 16
Passaic River at, flow of 20
rainfall at 32, 33
Pequanac River, course and character of 16
dam on, view of 44
drainage area length, fall, and gradient of 19
flood flow of 37, 41
flow of 27
profile of 18
Plainfield, rainfall at 32, 33
Pompton, dam on Pequanac River near, view of 44

Page.
Pompton, gaging stations at, views of ... 42
Pequanac River at, flow of ... 27
Ramapo River at, fall of ... 15
Wanaque River at, flow of ... 27
Pompton Furnace, height of water at ... 35
Pompton Lake, falls at ... 24
Pompton Plains, Pompton River at, flow of ... 27
Pompton River, drainage area, length, fall, and gradient of ... 19
flow of ... 20, 22, 24, 26, 27, 29
Precipitation. *See* Rainfall.
Rainfall in Passaic Valley ... 31–34
Ramapo River, course and character of ... 15–16
drainage area, length, fall, and gradient of ... 19
flood flow of ... 37, 41
flow of ... 27
height of water in ... 35
profile of ... 18
Ringwood, rainfall at ... 32, 33
Rivervale, rainfall at ... 32, 33
Rockaway River, course and character of ... 17
drainage area, length, fall, and gradient of ... 19
flood flow of ... 37, 41
flow of ... 27
measurement station on, view of ... 38
profile of ... 18
rise of ... 34
view of ... 30
Roseland, rainfall at ... 32, 33
Rutherford, high-water mark at ... 46
Saddle River, course and character of ... 15
drainage area, length, fall, and gradient of ... 19
Saddle River, flood flow of ...
profile of ...
Sherred, M. R., acknowledgments to ...
Singac, submerged flat lands at, view ...
South Orange, rainfall at ...
Stanley, measurement station at, view ...
Passaic River at, flow of ...
Two Bridges, flood at, view of ...
Passaic River at, flow of ...
Pompton River at, flow of ...
Vermeule, C. C., acknowledgments to ...
quoted on flood of 1882 ...
reference to ...
Wallington, flood at, view of ...
high-water mark at ...
losses at ...
Wanaque River, course and character ...
drainage area, length, fall, and gradient of ...
flood flow of ...
flow of ...
gaging stations on, views of ...
Watson, R. M., acknowledgments to ...
aid by ...
Water, height of ...
Wet lands, area of ...
Whippany, measurement station at, view of ...
Whippany River at, flow of ...
Whippany River, course and character of ...
drainage area, length, fall, and gradient of ...
flood flow of ...
flow of ...
measurement station on, view of ...
profile of ...

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